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FROM THE MAKERS OF *BBC FOCUS MAGAZINE*

THE SECRETS OF NATURAL REMEDIES

THE ULTIMATE GUIDE TO STAYING HEALTHY AND HAPPY FROM SUPERFOODS TO ALTERNATIVE THERAPIES

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WELCOME

Superfoods, stress busting techniques, herbal remedies, health hacks, meditation, mystic Eastern practices. Our lives are forever bombarded by brands and social media trying to sell us tips and tricks for leading a healthier, happier life – the natural way. Wading through this information overload can be exhausting. In this special issue, we've extracted the science and interviewed the experts to give you the low down on which natural remedies are worth spending your hard-earned cash on – and which to avoid.

Some natural remedies have been popular in some cultures for centuries – like acupuncture or yoga – while others have only recently grown in popularity, such as the rise of superhero superfoods. But the big question is which ones work – and which don't. Well, it depends on who you talk to. Science backs up a number of natural remedies, while for other lotions, potions, or practices, scientists can't find any rhyme or reason why they make us feel so good – it may simply be the placebo effect (see page 89) at work.

You might think that a remedy, which isn't supported by science but has been recommended by a friend (or tenacious marketer), is perfectly harmless – and, if the placebo effect works for you, why not go for it? But the bad news is that some of these natural remedies or alternative therapies are actually detrimental to your health – and, in certain cases, can cause serious harm. The fact that they've been practised throughout history doesn't cut it – remember how blood-letting was a popular therapy for centuries?

So, what about staying fit and the food on our plates? Which fads are worth the hours in the gym or indulging yourself in?

On page 10, discover the Science of Superfoods. From kale to quinoa, salmon to spinach, find out which foods deserve the 'super' prefix. In Health Hack or Quack, on page 18, find out which renowned (and lesser known) herbal remedies really work. Sneak preview: high five to the new beauty fad – anti-ageing argan oil – and thumbs down to evening primrose oil.

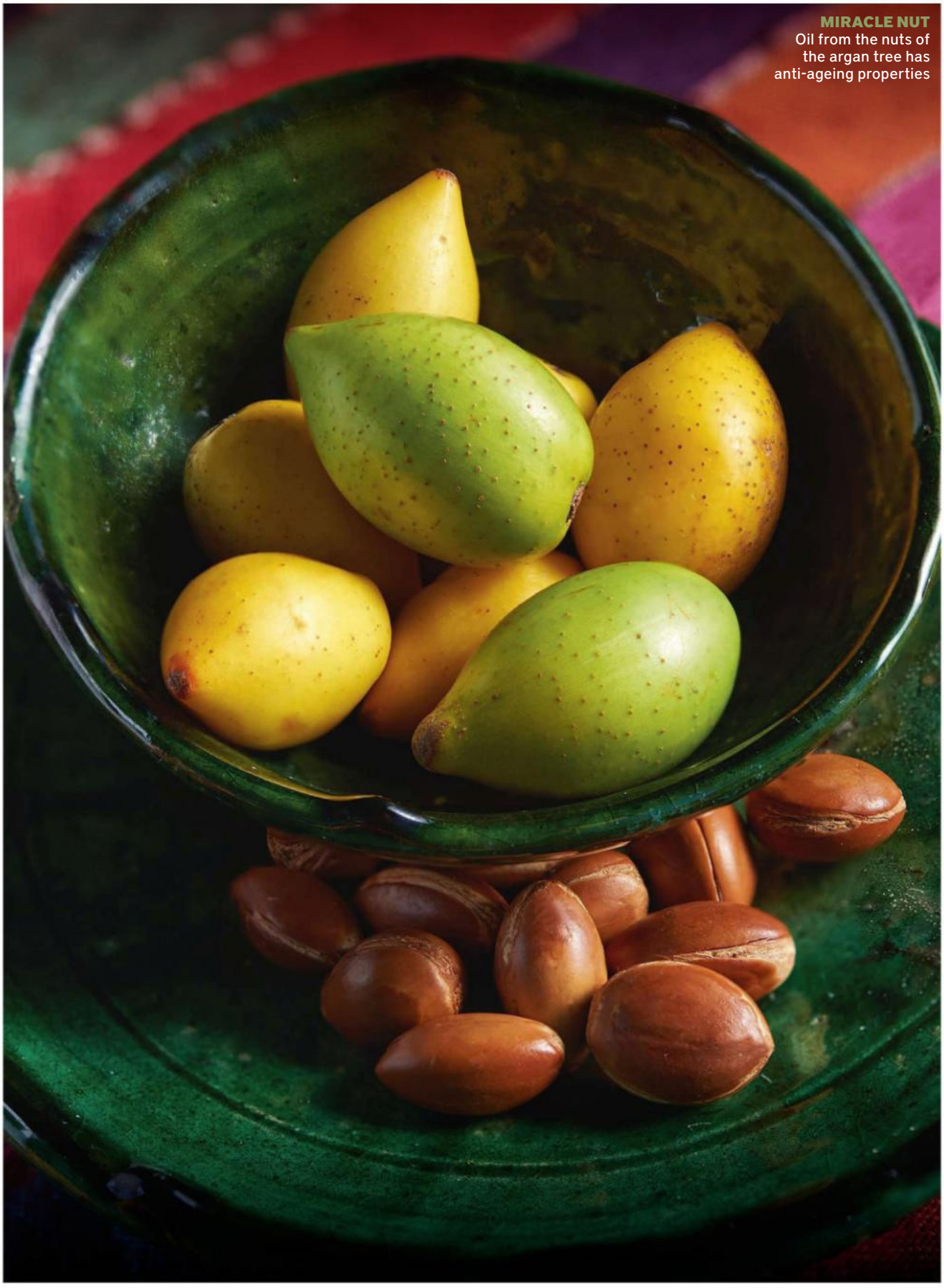
On page 26, discover why bacterial bugs are actually good for you and, on page 62, dive into shallow seas and explore the depths of the jungle as you go bio-prospecting for new natural remedies from the wild.

Plus, answers to key health questions (page 70), exercise secrets to boost the body and bust the belly (page 40), and natural remedies that help through pregnancy and birth (page 48). Chill out with stress-busting tips (page 54), find out about the history and science behind mystic Eastern practices (page 80). And, discover the truth about acupuncture (page 86), chiropractic therapy (page 94) and other alternative medicines (page 100). Finally, on page 106, explore the inner workings of your mind as you discover the science behind how mindfulness meditation works.

And breathe...ommm.

Daniel Bennett

Daniel Bennett, Editor



MIRACLE NUT
Oil from the nuts of the argan tree has anti-ageing properties

ALAMY

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The Science of *Superfoods*

Kale and chia, goji berries and blueberries, salmon and spinach. **JAMIE MILLAR** investigates the science behind whether superfoods are the magic bullet that can cure all our ills, and which ones deserve their 'super' prefix

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Billed as the superheroes of the culinary world, today, superfoods are as widespread as comic-book films – every day a new one hits our plates.

"There is neither a regulatory nor scientific definition of a 'superfood'," says Dr. Jeffrey Blumberg, from the Friedman School of Nutrition Science and Policy at Tufts University, Boston. "It is a marketing term which marketers apparently do not wish to define either." However, through an equally unscientific survey of the books and blogs that liberally sprinkle the term – more on those later – some common characteristics of these so-called superfoods can be discerned.

Superfoods typically have high levels of certain nutrients – such as the goji berry, which boasts more vitamin C than oranges, more beta carotene than carrots and more iron than spinach. They are often exotic in origin – the goji berry hails from the Himalayas. "This seems to suggest that they have some special health-promoting properties," says Dr. Blumberg. "Although the countries from which they come are not characterised by especially healthful or long-lived people."

Be ready to fork out

Indeed, superfoods are often rediscovered and repackaged staples of ancient civilisations, which also lends them credibility and a quasi-mythical air, even though those ancient civilisations are long-dead. Like the goji berry, which allegedly helped Chinese herbalist Li Ching Yuen live to the ripe old (unverified) age of 256. Coincidentally, he also sold goji berries. Which leads us to perhaps the defining characteristic of most superfoods – they're expensive.

The appetite for superfoods is growing – according to the International Food Information Council, nearly nine in 10 Americans are interested in foods that have health benefits beyond basic nutrition (what the IFIC calls 'functional foods'). But they're also swallowing some unsubstantiated claims. Legends of doctors discovering remote mountain tribes of age-defying, goji-munching centenarians should self-evidently be taken with a large pinch of pink Himalayan sea salt – another superfood with little scientific backing to elevate it above the table variety. But there's scarcely a grain of proof for the efficacy of the goji berry or any other superfruit.

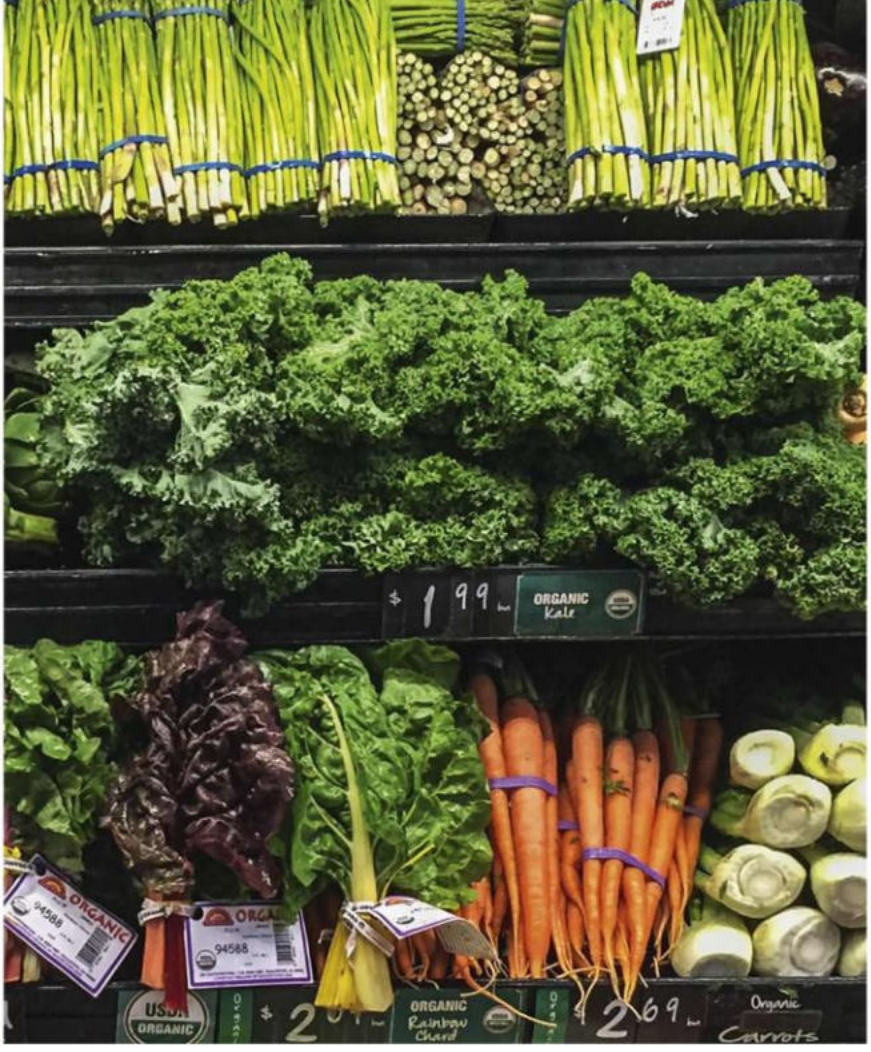
A 1994 Chinese study of 79 patients with advanced cancers found that their conditions regressed when treated with goji polysaccharides – in conjunction with immunotherapy. But information about the design of

GOJI BERRIES Popular among celebrities from Madonna to Miranda Kerr, goji berries have high levels of certain nutrients GETTY IMAGES

the study and the compounds used is, like evidence for the majority of goji's Everest-sized claims, lacking. Another study, on goji juice's effects on brain activity, was only performed on 34 people, and inconclusive at that. Most of the various studies related to goji and immunity, heart disease, and life expectancy have been either small, or used concentrated extracts which would be unrealistic – not to mention costly – to eat the equivalent of in real life.

Free radicals

Like many superfoods, such as açaí and blueberries, goji berries are touted as being high in dietary antioxidants. "They act to quench reactive oxygen, nitrogen and halide species – often called 'free radicals'," explains Dr. Blumberg, who is also the senior scientist at Tufts' Antioxidant Research Lab in the US. Free radicals are commonly cited as causing cancer – the marketing goes then that more antioxidants means less cancer. The science is not so straightforward. "Many free radicals play important, positive roles in cell biology and human physiology," says Dr. Blumberg. "In excessive amounts, though – generally referred to as 'oxidative stress' – they can damage cell constituents like lipids, proteins, and DNA, and contribute both to the aging process and the development of many chronic diseases, including cancer. However, this simple concept is actually extraordinarily complex, and incompletely understood."



GREEN GIANTS Vegetables are known to contain all sorts of beneficial vitamins and minerals. For example, kale has been found to lower the risk of cancer and heart disease

For one thing, more is not always better. "While consuming more antioxidant-rich fruits, vegetables, whole grains, nuts and seeds can certainly be good, everything can be harmful at a high enough intake," says Dr. Blumberg. One study on people at risk of developing lung cancer had to be stopped because those given antioxidants were dying more quickly. But while a diet that's high in antioxidant-rich produce probably won't do you much harm – unless you consume them in wine form – they won't necessarily do you that much good either. "While antioxidants are what marketers focus on, the science does not indicate that they're the most important part of a food's nutritional repertoire," says Kamal Patel, a nutrition researcher and director of examine.com, an independent study analysis website. "The federal government used to use the ORAC antioxidant scale, but no longer does due to lack of support for its impact on health."

Nor will the presence of high levels of antioxidants in a food, super or otherwise, necessarily result in a proportional antioxidant effect. For example, anthocyanins, found in the blueberry – often referred to as the grandaddy of the superfood movement – have been shown to inhibit growth of cancerous human colon cells in vitro. But there's no evidence that the flavonoids, the class →

The goji berry boasts more vitamin C than oranges, more beta carotene than carrots and more iron than spinach

GETTY IMAGES

of antioxidants that anthocyanins belong to, are even absorbed in the human body – indeed, studies show that less than five per cent survives consumption and is promptly excreted. "When you consume an antioxidant, the main antioxidant effect often comes from your body's reaction to consuming a foreign substance, rather than from the substance itself," says Patel. "Plus, our body's own antioxidant systems – involving compounds like glutathione – are more powerful than what we can get from food."

Tricky to study

The proof of the superfood pudding is in the eating – by humans, not mice or rats. But unfortunately, most scientific research is not conducted this way. "Nutrition studies often don't apply to real life on a 1:1 basis," says Patel. "If you want to test, say, the effect of grape juice on cognition, you'd give it enough time, plus you'd check to make sure they actually drink it. In real life, that almost never happens." Lifestyle factors are difficult if not impossible to separate. And there are other problems, says Patel: pilot studies and animal trials will often use larger dosages, while 'acute' studies will look at just the food without any other things consumed. Meanwhile, eating different foods together, which is what most of us do, can dramatically alter their effects for better or worse: "Co-consumption makes things more complicated."

Another issue affecting superfood research is that it is often paid for by interested parties. "We're funded by food and supplement companies in many of the studies we conduct," admits Professor David Nieman, Director of the Human Performance Labs at Appalachian State University in North Carolina. "But the North Carolina university system demands contractual agreement that gives the primary investigator 'academic freedom', or the right to publish the data, positive or negative. Many of the companies I work with are so convinced that their product has special effects that they sign these agreements." What buyers should beware of are studies conducted *in-house* by companies, which are "close to worthless", says Prof. Nieman. But while industry-funded doesn't mean false, the anointed superfood might not be much better than a cheaper, less exotic equivalent that doesn't have the same commercial imperative (see page 17).

The problem is not that superfoods are a con – many are highly nutritious – but calling them 'super' gives unrealistic expectations

The problem is not so much that superfoods are a con – many of them, like chia seeds (right) or kale, are highly nutritious – more that calling them 'super' gives unrealistic expectations of what they will do. "I prefer the concept of 'high nutrient density' foods, which is a central theme in the new 2015-2020 dietary guidelines for Americans," says Prof. Nieman. "The term 'superfood' is not used by most scientists in the field, because the implication is that one can expect quick and high-end health benefits." By all means, sprinkle some chia seeds on your oatmeal, and even stir in some blueberries. You'll get a nutritional boost, you just won't instantly become immortal: "What matters is the habitual eating pattern over months and years."

The blueberry is often referred to as the grandaddy of the superfood movement

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A balanced diet

By seeing superfoods as a magic bullet, we risk shooting ourselves in the foot. "Some people think if they eat one 'superfruit', they don't need to eat the recommended 2-4 servings of fruit a day," says Dr. Blumberg. But no one superfood is a panacea; nor will it make up for other deficiencies. "Adding superfoods to a good diet is fine," says Dr. David Katz, Director of Yale University's Prevention Research Center in the US. "Counting on them to compensate for a bad diet is not." And undue emphasis on superfoods can be unhealthy. "The term helps companies sell product, and it 'helps' consumers oversimplify their diets," says Patel. All the experts cited here stressed the importance of consuming a wide variety of natural, 'whole' foods, which in turn reduces their individual significance. "No single food or beverage is important enough to stand out from the overall lifestyle," says Prof. Nieman. →

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Inflated health benefits

The chia seed is a good example of how claims about superfoods can grow out of all proportion

A variety of mint, over recent years chia has broken out of those novelty pet-shaped pot plants to become an Aztec warrior miracle food. It's a complete protein with all the amino acids required to build muscle, plus more omega-3 than salmon, more fibre than flaxseed, and wealthier than Montezuma himself in antioxidants and minerals. Indeed, cheerleaders of chia allege you could eat it and nothing else.

"It's a good example of how companies and distributors promote the mystique and magical health benefits that go way beyond the science," says Professor David Nieman, Director of the Human Performance Labs at Appalachian State University in North Carolina. "We conducted several randomised human trials showing that chia seeds provide good nutrition and can be included in a healthy eating pattern that over time – along with physical activity and weight management – is consistent with good health. But there's nothing quick or miraculous about them."

SOUTHERN CLIMES
Fields of the crop quinoa lie in front of a majestic mountain range in Chile

Another unintended consequence of the fashionable superfood label can be felt in their countries of origin as they attain trendy status in the developed world. Quinoa, aka 'the miracle grain of the Andes', tripled in price between 2006 and 2011, becoming too expensive for many in its native Peru and Bolivia. Diversity of crops also takes a hit as farmers jump on the lucrative bandwagon. And, ironically, people in those countries wind up eating more imported junk food, because it's cheaper. (However, quinoa is now being grown in the UK.) Meanwhile, the Ethiopian government recently lifted a ban on the export of teff (a gluten-free super-grain), which was imposed in 2006 amid fears of a grain shortage. They're increasing yield by 40 per cent first to ensure adequate supply, but there are still concerns.

Superfoods can be costly for us too – they drive us to spend more, feed the untrue notion that healthy eating has to be expensive, and lead us to overlook other beneficial foods.

"Açaí and other exotic-sounding foods haven't been shown to be healthier than other foods, and there are few if any long-term studies on their effects on disease," says Patel.

If such things as superfoods exist, then they're hiding behind their secret identities as the mild-mannered Clark Kents of the supermarket produce section. "Garlic has a tonne of evidence," says Patel. "Potatoes are cheap, nutritious and filling, yet they don't get much attention – or they get negative attention, because they have white flesh."

> Potatoes are cheap, and nutritious, yet they don't get much attention – or they get negative attention

Ultimately, while superfoods may be a misnomer, we shouldn't throw the broccoli out with the coconut water (a sugary waste product of farming that is no better for rehydration than plain old H_2O).

"The term is more about marketing than meaning," says Dr. Katz. "But, of course, there is no clear definition of 'junk food' either. Sometimes we understand terms without precise definitions. And being nutrient-dense does, in general, make a food better. There are complications in how nutrients are metabolised, of course. But that doesn't undermine the value of naturally nutrient-rich foods."

They just aren't necessarily the most heavily marketed ones. Or the most expensive. Rather than hero-worship particular superfoods, think of your diet as like *The Avengers*: a diverse assortment of colourful characters with different powers that work well together. And the largest part of it should be green. ■

GETTY IMAGES

Everyday heroes

They're not new or exotic, and they don't always grab the headlines. But if these widely available 'superfoods' aren't already in your kitchen, they should be

GARLIC

Better known for warding off vampires and first dates, there is evidence the bulb can lower blood pressure and cholesterol, plus even prevent colds and certain cancers.

EXTRA-VIRGIN OLIVE OIL

A Mediterranean mainstay, the healthy fats in this cure-oil cut cardiovascular disease and inflammation. But don't fry with it – high heat damages its nutrients.

BROCCOLI

Containing high levels of vitamin C and folate (natural folic acid), this fibrous cruciferous vegetable can stem cholesterol and triglycerides, which cause cardiovascular disease.

APPLE

Crunching this doctor-deterring fruit, which is high in antioxidants and fibre, has been associated with reduced risk of cardiovascular disease, diabetes, asthma and some cancers.

ONION

A member of the alium family, it contains a potent anti-inflammatory antioxidant called quercetin, which reduces blood pressure and cancer risk.

WALNUT

This has the highest antioxidant activity of any nut and is the only one with a significant amount of omega-3. A review suggests they could stave off cardiovascular disease.

TOMATO

Technically a fruit, it is low in starch and sugar, but high in fibre, vitamin C, beta-carotene and a potent antioxidant called lycopene. Cooking in olive oil increases its absorption.

BEET

Rich in iron and folate, beets can make you hard to beat – their nitrates lower blood pressure and your personal best time, while some studies show improved exercise performance.

SPINACH

Popeye's preferred superfood packs high levels of bone-strengthening calcium and vitamin K, as well as vitamin A, and almost as much iron as beef.

SALMON

Think pink. Oily fish reduces cardiovascular disease risk, lowering blood pressure, and lubricating arterial fat build-up. Salmon is high in omega-3, vitamin D, some B vitamins and selenium.

GETTY IMAGES / ISTOCKPHOTO

Health *Hack* or *Quack*

In this A-Z of popular herbal remedies, **LUIS VILLAZON** sorts fact from fiction, revealing which work and which are pure hype

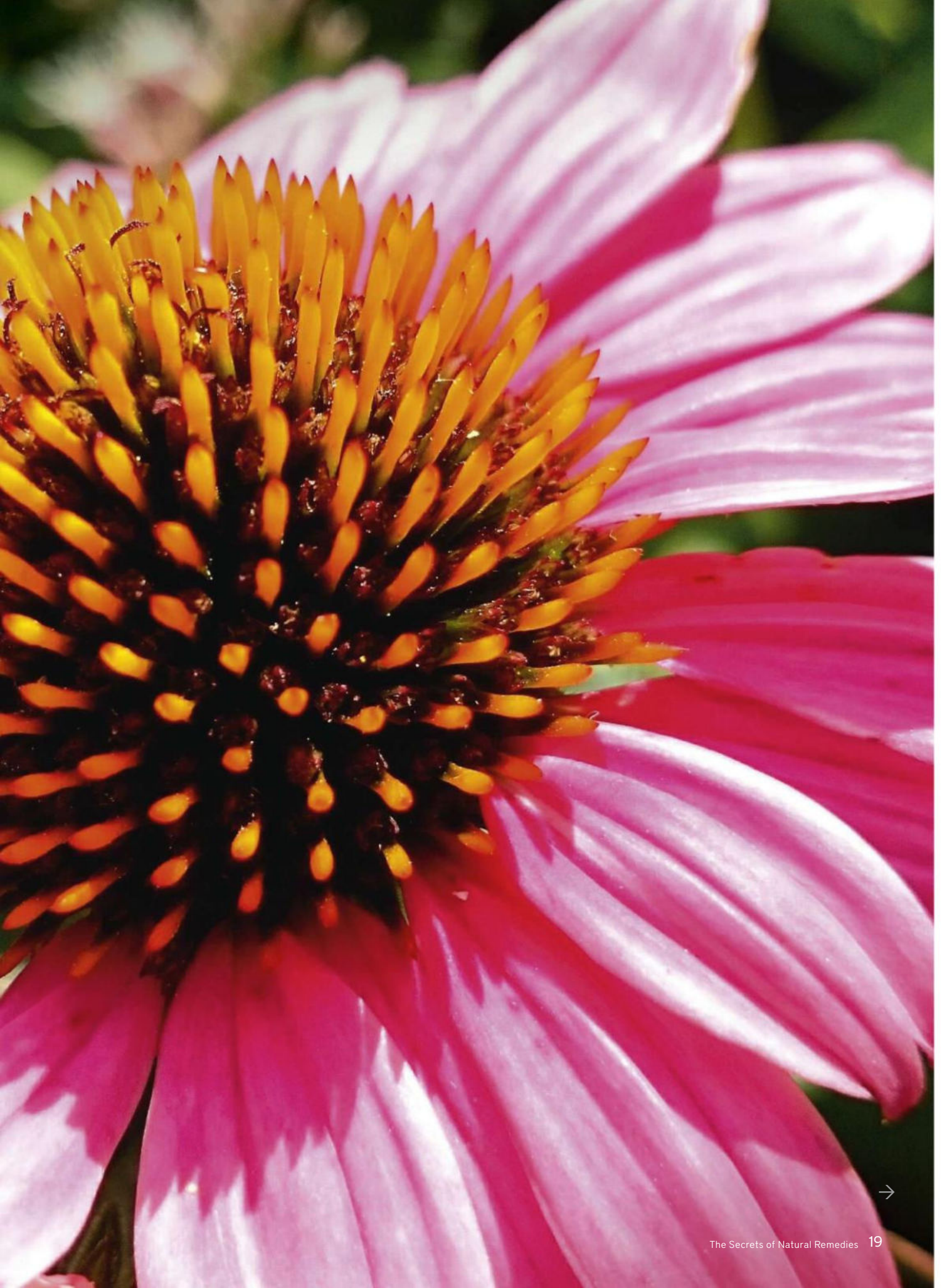
What the scores mean

We looked at the available scientific research to determine how much evidence there is for any claimed health benefits of each herbal remedy.

■□□□□ Placebo (see page 89)
■■□□□ Mostly hype
■■■□□ Conflicting evidence
■■■■□ Seems promising
■■■■■ Cure

GETTY IMAGES

Echinacea purpurea, commonly known as the purple coneflower



The yellow fruit of the argan tree, *Argania spinosa*, which contains the argan nut

A IS FOR ARGAN OIL

The argan nut grows in Morocco on those thorny trees that goats climb. It's added to many cosmetics and toasted argan oil is also used in cooking. The oil contains antioxidant vitamin E, and linoleic acid, which has anti-inflammatory properties. A recent study found that it improves the elasticity of the skin of postmenopausal women – making it look younger and wrinkle-free. This seems to work whether it's applied as a cream or taken internally, so you might as well eat it because it can also lower your blood cholesterol.

RATING ■■■■□

B IS FOR BEE POLLEN

Bee pollen is just ordinary flower pollen that happens to have been collected by bees. It's a mixture of sugar, protein and fat, which makes it a fairly high-energy food source, but that's about it. The claims that it is an effective treatment for cancer, or that it can boost athletic or sexual performance, is not backed up by any hard scientific data.

RATING ■□□□□

It's a myth that pollen collected by bees can treat cancer

GETTY IMAGES

C IS FOR CHLORELLA

Chlorella pyrenoidosa is a single-celled freshwater alga that has been explored as a potential food source, because it is high in protein and calories. As a medical supplement though, the benefits are much less convincing. Several studies have looked in vain for antioxidant, blood pressure lowering or weight loss effects. There is some very limited evidence that it might boost the immune system, and reduce the symptoms of fibromyalgia, but a lot more research would be needed to confirm these effects.

RATING ■■□□□

D IS FOR DONG QUAI

Also known as 'female ginseng', dong quai is a relative of the angelica plant. It is sometimes prescribed by practitioners of Traditional Chinese Medicine for symptoms of menopause or painful menstruation. Some laboratory research has shown that it relaxes the muscles of the uterus and opens blood capillaries, but studies that looked for actual therapeutic benefits in human patients have generally found it is no better than a placebo. And it may even be dangerous in some circumstances, since it's been shown to interfere with blood clotting.

RATING ■□□□□

E IS FOR ECHINACEA

Also known as purple coneflower, *Echinacea purpurea* contains polysaccharide compounds that are thought to increase the activity of the immune system. Several studies have attempted to test the herb as a treatment for the common cold, and the results are decidedly mixed. A large study in 2007, for example, found that it reduced both the duration of cold infections, and your chances of catching a cold. Meanwhile, two other studies funded by the National Center for Complementary and Integrative Health (part of the National Institutes of Health in the US) found no benefit.

RATING ■■■□□

F IS FOR FOLIC ACID

Folate or vitamin B9 can't be synthesised within the body so we have to obtain it from our diet. Since 1998, the FDA in the US has required that folic acid is added to bread, cereal, rice, pasta and flour. Folate is particularly important during the early development of the foetus, so woman of childbearing age are recommended to take an extra 0.4 mg/day to reduce the risk of neural tube defects and premature birth. Surprisingly, a 2013 study in mice found that the foetus can also be affected by the low folate levels in the father's diet. Folic acid can affect which genes in the sperm are activated, so a B9 supplement or a healthy diet rich in dark leafy vegetables is important for prospective fathers too.

RATING ■■■■■

GETTY IMAGES

The herb Echinacea is extracted from the purple cone flower, *Echinacea purpurea*

G IS FOR GREEN-LIPPED MUSSEL EXTRACT

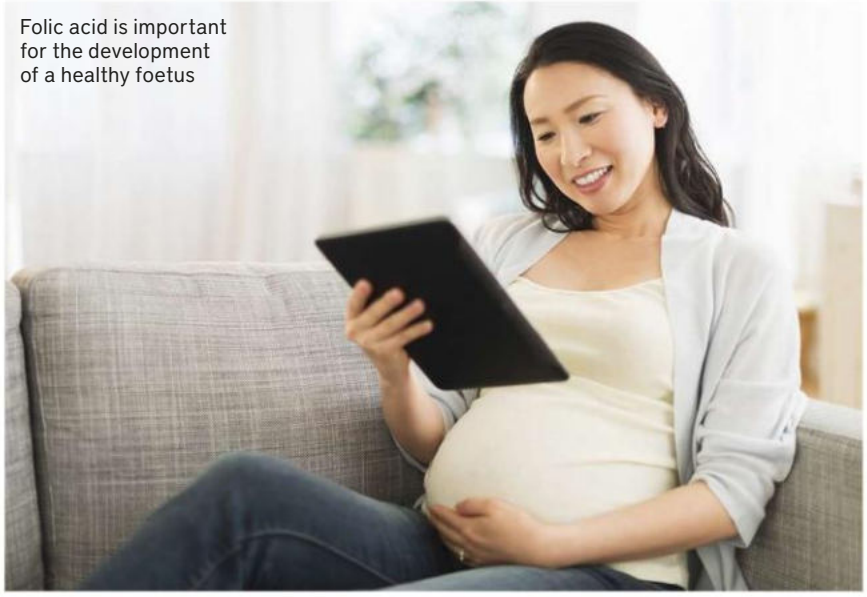
New Zealand green-lipped mussels contain certain fats that are known to have an anti-inflammatory effect. Because of this, green-lipped mussel extract has been studied as a possible treatment for arthritis. The evidence isn't very strong, however. Several comprehensive reviews of multiple studies have concluded that it is no better than a placebo. This might be because the active ingredient degrades once it is extracted into pill form.

RATING ■■□□□

H IS FOR HYALURONIC ACID

You have around 15g of hyaluronic acid in your body right now. It's a large molecule that acts as a lubricant and a filler in the skin, eyes and joints. Hyaluronic acid is used by plastic surgeons to plump out lips and it's a common ingredient in skin moisturising creams. There's no evidence that taking hyaluronic acid orally has any anti-aging effect on the skin, but some studies have shown that it reduces the symptoms of arthritis in the knee.

RATING ■■■□□

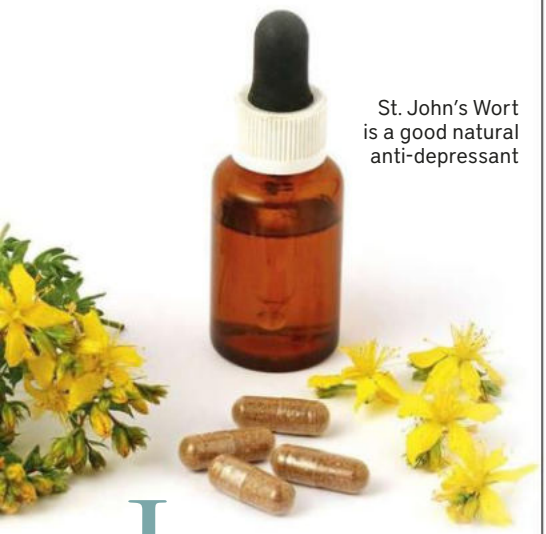


Folic acid is important for the development of a healthy foetus

I IS FOR IRON

Iron deficiency is the most common nutritional deficiency in the world, but in the UK it is rare because foods, such as bread, are often fortified with iron. A 2012 study found that adult women may be mildly iron deficient even if they are not medically anaemic, and taking iron supplements reduced how tired they felt. However, the effect was very small, and too much iron is certainly harmful. Accidental overdoses of iron supplements are a leading cause of child poisoning deaths in the US, so keep your tablets locked safely away.

RATING ■■■■□



St. John's Wort is a good natural anti-depressant

J IS FOR ST. JOHN'S WORT

Several large-scale reviews of studies involving St. John's Wort have concluded that it is more effective at treating depression than standard anti-depressants. The results of individual trials vary wildly, though, in part because the amount of the active ingredient in St. John's Wort tablets can differ from the amount claimed on the bottle by a factor of two or more.

RATING ■■■■□

The nectar from the Manuka tree in New Zealand can be made into honey

K IS FOR KRILL OIL

Red krill oil comes from the shrimp-like crustaceans that whales eat. It contains eicosapentaenoic acid and docosahexaenoic acid, commonly known as omega-3 fatty acids – well known for reducing the risk of heart disease. It's claimed that krill oil is more effective than fish oil, but the evidence is much less conclusive. It may be that the slightly different chemical composition of the omega-3 in krill oil makes it more easily absorbed, but even if true, it would only mean you need a smaller dose to achieve the same effect.

RATING ■■■□□

L IS FOR L-CARNITINE

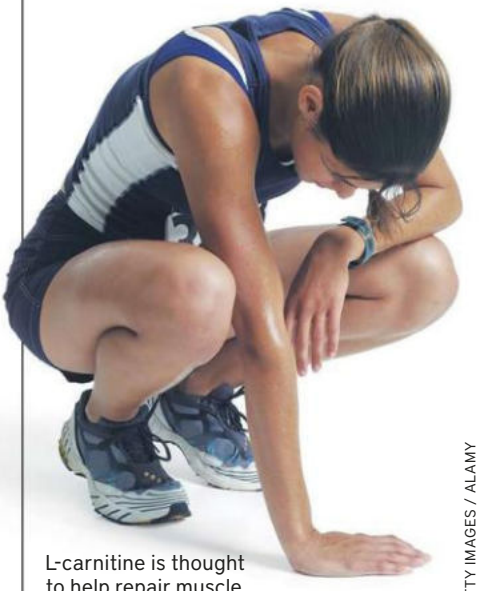
Carnitine is an amino acid used by virtually all your cells in the release of energy. It's produced in the body, so normally there's no need to take it as a supplement. There is some evidence that taking L-carnitine (which is the biologically active form) can improve sperm function, and it may also help repair muscle damage following exercise. Research doesn't support other claims that it boosts athletic performance or increases muscle mass.

RATING ■■■■□

M IS FOR MANUKA HONEY

Honey is a broad spectrum antibiotic, but we still don't fully understand how it kills bacteria. Manuka honey is made from the nectar of the New Zealand Manuka tree and has the strongest antibacterial effect. But lab studies have so far failed to translate this into significant benefits in human patients. Manuka honey dressings might shorten healing times slightly for moderate burns, but the evidence for other wounds is quite weak.

RATING ■■■□□



L-carnitine is thought to help repair muscle damage post exercise

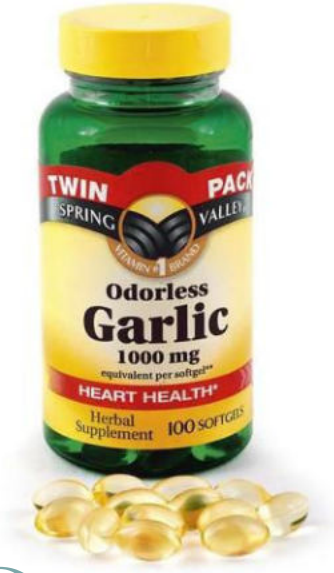
GETTY IMAGES / ALAMY

N IS FOR NETTLE

There is some evidence that stinging nettle root is effective against male urination problems caused by an enlarged prostate, such as difficulty urinating or incontinence. We don't know how this works yet, because other studies have shown that nettle definitely doesn't actually reduce the size of the prostate. Nettle also has an antihistamine effect, and some studies have found that it helps against osteoarthritis and hay fever.

RATING ■■■■□

Nettle root has been found to help combat hay fever and osteoarthritis



O IS FOR ODOURLESS GARLIC

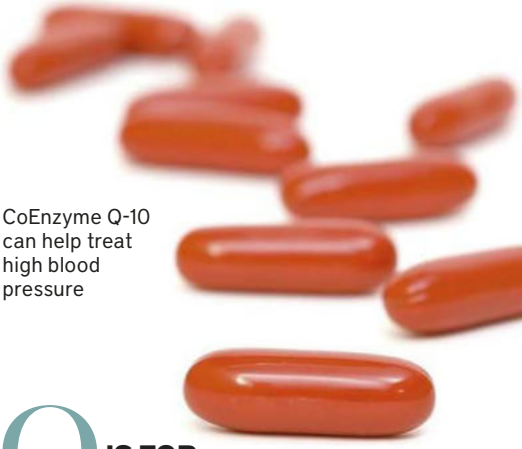
Diets naturally high in garlic are known to be associated with low incidence of colon cancer, and there is some evidence that taking garlic in an odourless capsule form provides the same protection. Garlic capsules also seem to lower blood pressure slightly, but we still don't know if this results in fewer deaths from heart disease. And an extensive study at Stanford in the US, published in 2007, found that garlic, in any form, does not reduce blood cholesterol.

RATING ■■■■□

P IS FOR PRIMROSE OIL

Extracted from the seeds of the evening primrose plant, it contains gamma-linolenic acid (GLA), which is also found in borage oil and blackcurrant oil. Evening primrose has been heavily promoted in the past as a treatment for pre-menstrual syndrome (PMS) and eczema. The US National Institute of Health and the FDA both agree, however, that there isn't enough evidence to support either claim. There are some studies that did find a benefit, but these have subsequently been criticised as poorly designed. Most of the research in support of evening primrose was sponsored by Efamol Ltd – a company that marketed the supplement – and the *British Medical Journal* has since called evening primrose oil "the remedy for which there is no disease".

RATING ■■□□□



CoEnzyme Q-10 can help treat high blood pressure

Q IS FOR Q-10

Coenzyme Q-10 is produced naturally in the body and is used by the mitochondria in your cells to produce energy. Studies show that it can be an effective treatment for chronic heart failure or high blood pressure. But the evidence for its usefulness against a wide range of other diseases including cancer and fibromyalgia is currently inconclusive.

RATING ■■■□□

GETTY IMAGES / ALAMY

R IS FOR RASPBERRY KETONE

This chemical is used as a flavouring in the food industry, but it is also sold online as a weight-loss medicine. Studies in rodents have shown that at very high doses, raspberry ketone alters the metabolism to increase the rate at which fat is burned. But there is no evidence that this works in humans.

RATING ■■□□□

The spiky fruit of the plant *Tribulus terrestris*

Spirulina is known for being a good source of protein

S IS FOR SPIRULINA

Made from dried blue-green bacteria, spirulina is a good source of protein (although it doesn't contain any vitamin B12). There are some lab studies that have shown possible immune system boosting effects, but these haven't been replicated in humans. One small-scale study found that spirulina was effective at treating chronic arsenic poisoning.

RATING ■■■□□

T IS FOR TRIBULUS TERRESTRIS

The puncturevine, or *Tribulus terrestris*, is a weed that produces small spiky fruits. Extracts of these fruits have been shown to increase testosterone levels in rodents. This doesn't seem to happen in humans, though. Studies have failed to show significant improvements in blood testosterone levels or muscle mass. A few small-scale studies have shown a limited improvement in male libido and erectile function.

RATING ■■□□□

U IS FOR UVA URSI

The bearberry plant, *Arctostaphylos uva ursi*, produces fruit that contain the hydroquinone compound arbutin. This is an antibacterial that passes into your urine, and one study found it can be effective against urinary tract infections, but there is limited research into its effectiveness in humans. Hydroquinones can also cause liver damage in high doses, so using it for more than five days, or more than five times in one year is not recommended.

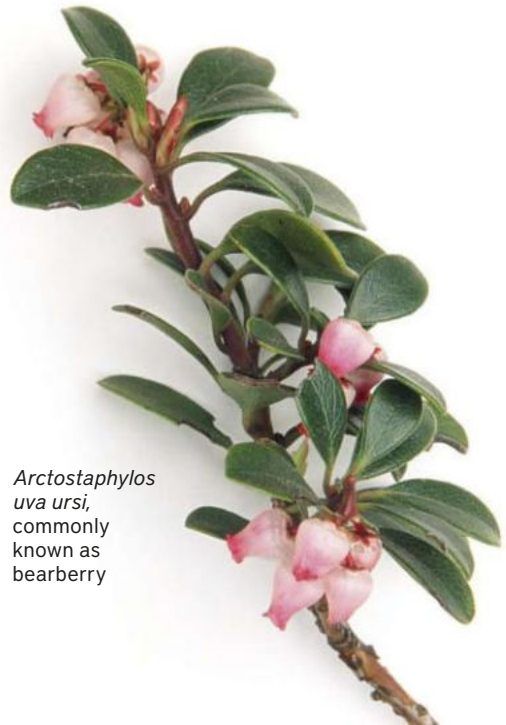
RATING ■■□□□

V IS FOR VITAMIN K2

Vitamin K is found in plants and is important for blood clotting and strong bones. K2 is the bacterial form of vitamin K, and has similar effects in humans when taken as a supplement. There is good evidence that it slows the rate of bone density loss in the elderly, although less effectively than hormone therapy in menopausal women. A few studies have also shown that high doses may be helpful in treating liver cancer.

RATING ■■■■□

GETTY IMAGES / ALAMY

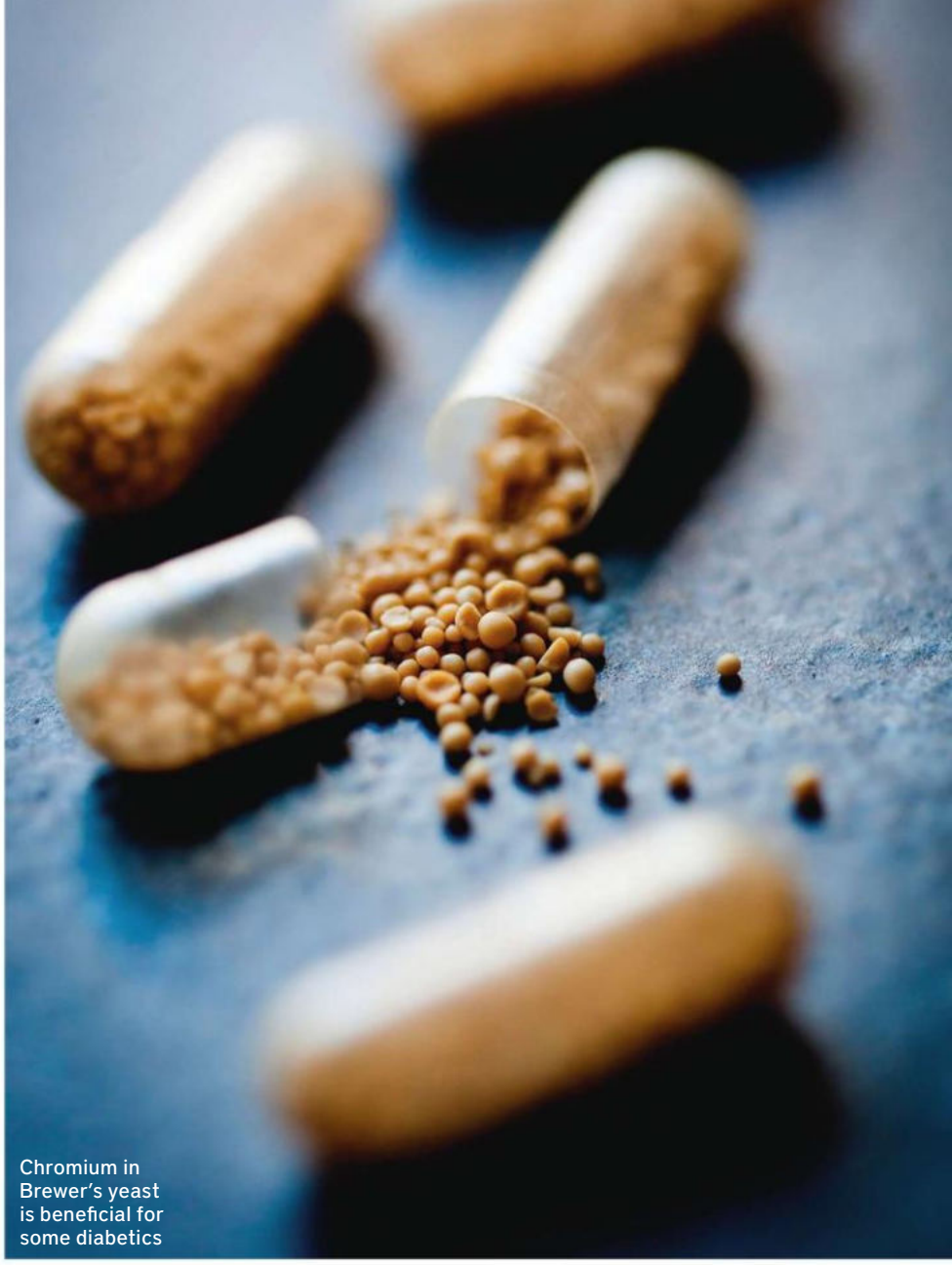


Arctostaphylos uva ursi, commonly known as bearberry

W IS FOR WHEATGRASS

Wheatgrass is simply the leaves of the young wheat plant. It contains roughly the same nutrient content as the same weight of spinach or broccoli. As a food, it's fine, if a little unpleasant tasting. As a medicine, the evidence is very weak. Some small studies have found that it reduces the symptoms of ulcerative colitis and the side effects of chemotherapy, but most of the claims that it rids the body of toxins or oxygenates the blood are not supported by science.

RATING ■□□□□



Chromium in Brewer's yeast is beneficial for some diabetics

American ginseng may lower blood sugar and boost the immune system

ALAMY

X IS FOR XI YANG SHEN

Also known as American ginseng, both this and Asian ginseng contain chemicals called ginsenosides and gintonin. Despite a long history of use in Traditional Chinese Medicine, the evidence for health benefits of ginseng is fairly weak. Some small trials have found it lowers blood sugar and boosts the immune system, but claims that it improves 'wellness', reduces stress or acts as an aphrodisiac are not backed by well-designed scientific studies.

RATING ■■■□□

Y IS FOR YEAST

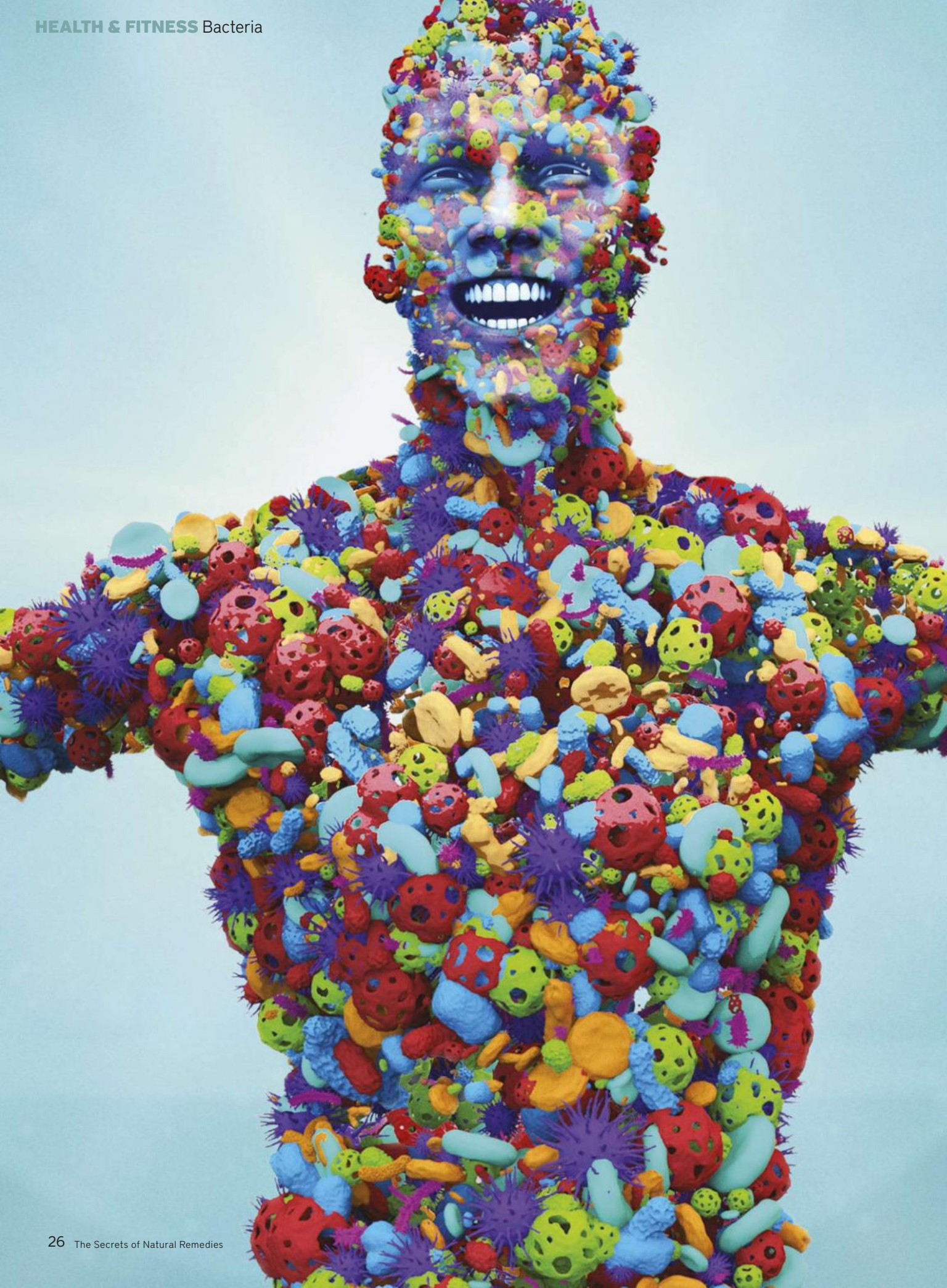
Brewer's yeast (*Saccharomyces cerevisiae*) is a good source of selenium, chromium and B-complex vitamins (but not B12 – that's a myth). The most important micronutrient is chromium. Numerous studies have shown that it helps type 2 diabetes sufferers by increasing their tolerance to blood glucose and reducing the amount of insulin they need. There is also some limited evidence that it lowers the LDL 'bad' cholesterol and raises HDL 'good' cholesterol.

RATING ■■■■■

Z IS FOR ZINC

Over 300 enzymes in your body require zinc to function. Dietary deficiency is more common in vegetarians, because phytates present in whole grains and legumes inhibit zinc absorption. Zinc supplements seem to help protect against age-related macular degeneration (AMD), and conflicting evidence suggests it may reduce the symptoms of the common cold. But zinc can be very toxic at high doses and interferes with antibiotic medication, so use supplements with caution. ■

RATING ■■■□□



THE POWER OF BACTERIA

Microorganisms are the perfect natural remedy to fend off many a malady. **NICOLA DAVIS** reveals how these tiny bugs protect your health – and even affect your mood

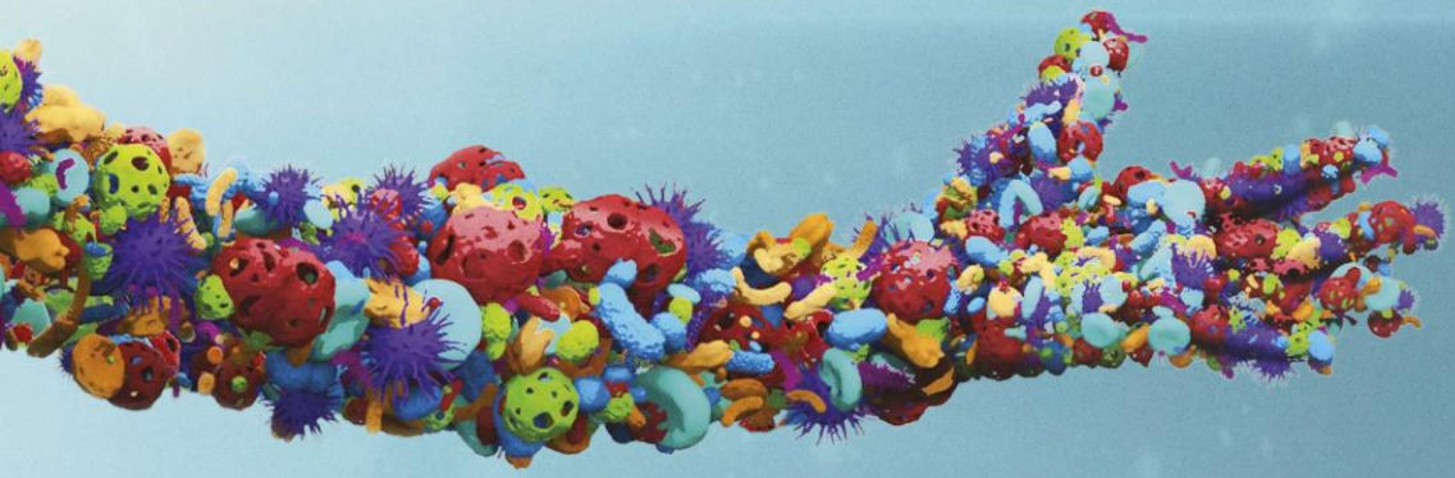
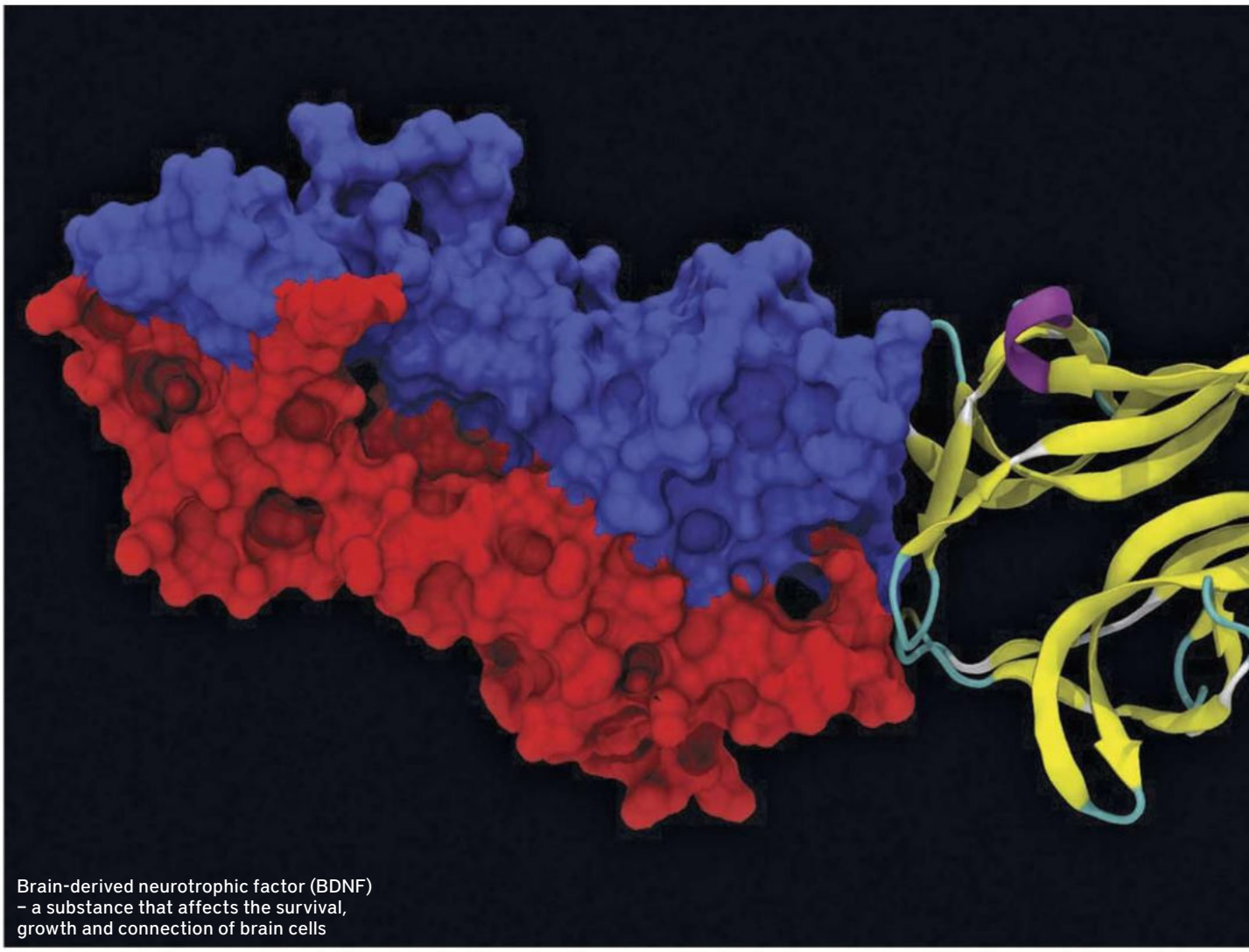


ILLUSTRATION: MAGIC TORCH

Bacteria. For many it's a dirty word, suggesting a collection of invaders to be obliterated with a lemon-fresh spray. Yet the staggering truth is that you are more bacteria than body – the gut alone holds over 100 trillion bacteria of myriad species, many of which help with breaking down food and play a vital role in immunity. In fact, you've been friends for a while. Most of your gut microbiota (including bacteria) initially came from your mother's birth canal as you entered the world, or from skin and the surrounding environment if you were born by caesarean. Once you're out in the open, multiple factors such as diet, antibiotics, genetics and stress will influence the microbiota. The upshot is a cornucopia of bugs that weighs about the same as a human brain. And perhaps that's fitting, for while it's long been known that the brain can influence the gut, modern science is showing that communication can go both ways. Indeed, recent studies have revealed that the gut microbiota could be involved in a host of conditions such as obesity, social behaviour deficits, Parkinson's disease and anxiety. That's right –



Brain-derived neurotrophic factor (BDNF) – a substance that affects the survival, growth and connection of brain cells

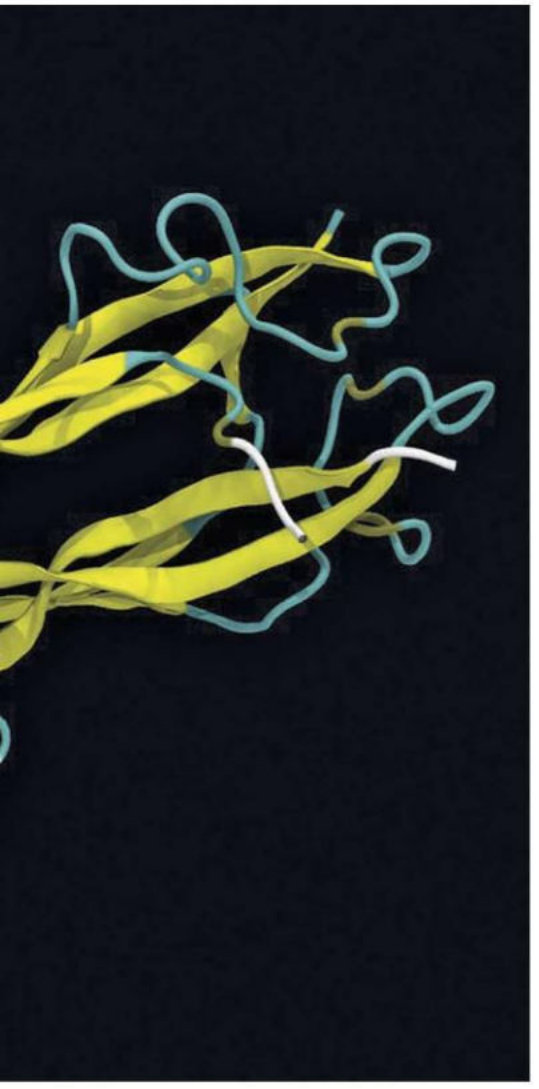
AYACOP, WIKI COMMONS

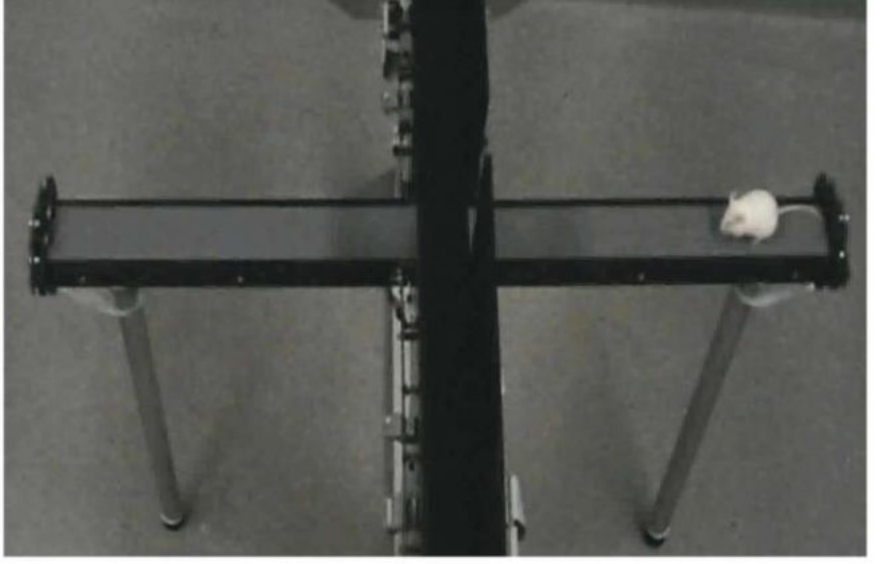
microbes might be meddling with your mood.

It's a hot topic of research that exploded just 10 years ago when a team of Japanese researchers delved into the gut microbiota of mice. But these weren't any old mice. They were raised in a sterile environment, therefore making them 'germ free'. This created a clean slate with which to study the brain and behaviour before and after bacterial colonisation. Surprisingly, the researchers found that the germ-free mice had greater amounts of stress-related hormones when restrained than animals with microbes. Yet when young germ-free mice were colonised by certain bacteria, their stress response changed. What's more, the germ-free mice also showed differences in the levels of a brain-derived neurotrophic factor (BDNF) protein – a substance in the brain that affects the survival, growth and connection of neurons (brain cells).

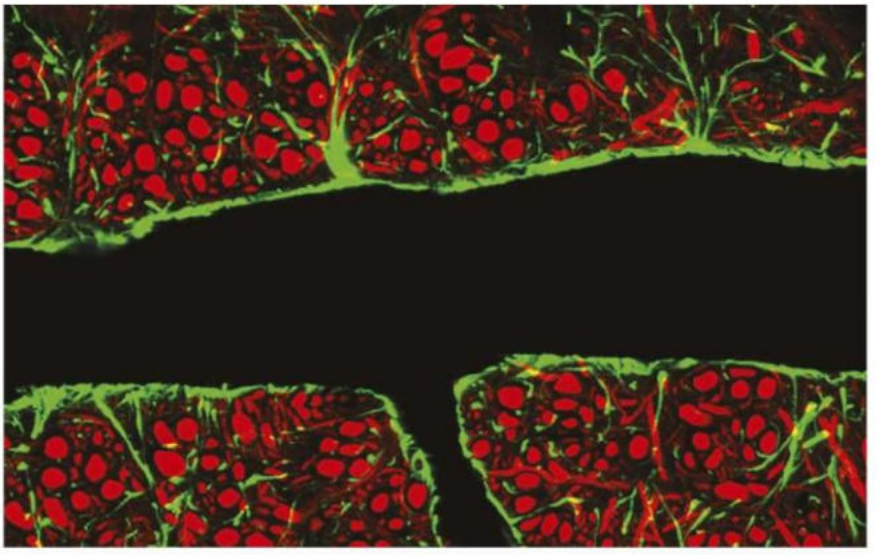
Germ-free mice had greater amounts of stress-related hormones when restrained than animals with microbes

A wave of research involving germ-free mice followed. One particularly intriguing study was carried out by Dr. Jane Foster and her colleagues from McMaster University in Canada. Using a cross-shaped maze, they found that germ-free mice spent more time hanging out in exposed areas than their bugged-up peers. This suggested reduced levels of anxiety, despite having increased levels of a stress-related hormone. Furthermore, the germ-free mice showed changes to the levels of BDNF-encoding molecules, which





ON TEST A germ-free mouse taking part in a study to monitor stress hormones, where scientists compare time spent on the exposed and hidden parts of the cross-shaped maze



CROSS SECTION Confocal light micrograph of a section through a blood vessel in the brain, showing the arrangement of cells that form the blood-brain barrier

SCIENCE PHOTO LIBRARY / UCLA

suggests the gut microbiota might tinker with how the brain is wired for anxiety. "We know what brain regions are involved, and what's interesting is those brain regions are changed in these manipulations of microbiota," says Dr. Foster.

The interesting relationship between microbiota and behaviour, however, is far from simple. Changes to levels of BDNF-encoding molecules appear to differ between sexes. Meanwhile, a recent study using one strain of rat found that the animals actually appeared to behave in a more anxious way when they didn't have gut microbiota. Studies have also found that infecting mice with populations of 'bad' bacteria can increase their anxious demeanour.

Nevertheless, the notion that bugs can affect behaviour is pretty mind-boggling. In one of the most astonishing studies, a team of researchers transferred gut microbes from an anxious strain of mouse into a germ-free mouse of a more adventurous strain – and vice versa. The result? A behaviour transplant.

Bugging out

Yet questions abound, especially regarding the significance of age. Indeed, some studies suggest that stress responses and anxiety levels in germ-free mice can only be altered by colonisation with bacteria if such exposure occurs when the animals are young. If the same effect is observed in humans, it could imply a need for interventions in childhood and pre-adolescence. Interestingly, the composition of our own gut microbiota is unstable until we reach about three years of age. "It's just developing, and that is also the same period of life when the brain is developing," states Professor Emeran Mayer, a gastroenterologist at the University of California, Los Angeles.

Interventions in elderly people might also be important because our gut bacteria levels naturally start to decline as we age. "The microbiota composition, diversity [and] abundance kind of reverses back to the way it was in childhood," says

Various bacteria species might influence mood in humans

Prof. Mayer. "So again it's quite possible that any manipulations or any influence on brain function will be greater at that time."

Exactly how the gut microbiota bring about changes to the brain and behaviour is far from clear-cut. "If I have a headache it could be because I bumped my head, or it could be because I am dehydrated. Those are two very different mechanisms where the readout is the same," says Dr. Foster. "It is the same thing here."

And the mechanisms are myriad. Among the mooted possibilities, gut bacteria – or the molecules they produce – could directly or indirectly interact with branches of the vagus nerve in the gut. They could signal to the brain, affect hormonal signalling routes, interact with the immune system, or trigger responses via pathways that include neurons within the gut lining and the vagus nerve. What's more, just a few months ago, researchers revealed that the gut microbiota could affect the permeability of the blood-brain barrier. It's a web of intrigue.

Mood swings

"There are so many different types of bacteria and they are all having very different effects on different aspects of physiology," says Professor John Cryan from the University of Cork.

In one study, scientists at McMaster University joined forces with Cryan and his team to probe the impact of the probiotic *Lactobacillus rhamnosus* on healthy mice. "It dampened down anxiety and made the animals more chilled out [and] changed the brain chemistry," Prof. Cryan explains. "When we cut the vagus nerve this didn't happen." But complexities are never far away. "Some of our colleagues in Canada have done similar studies with different bacteria and showed that it wasn't dependent on the vagus," he adds.

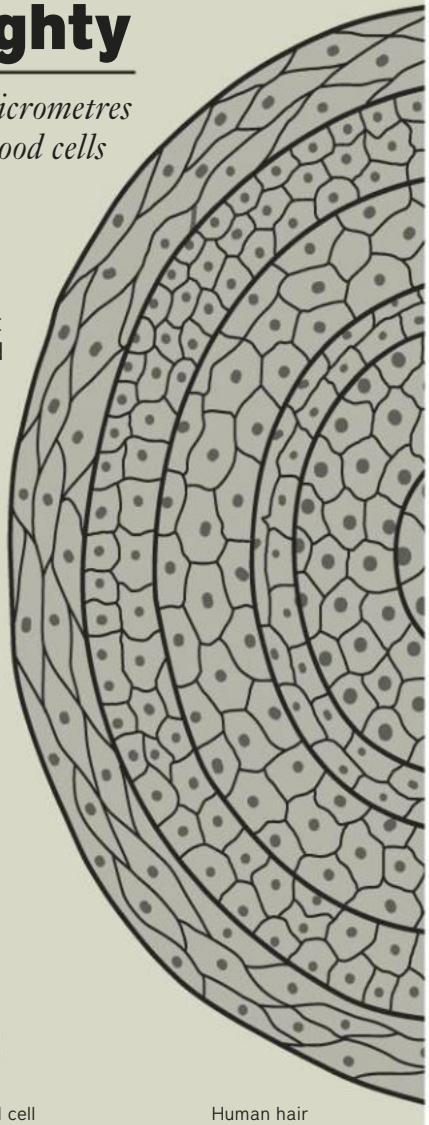
It's a problem worth probing. While human studies are few and far between, there is a tantalising suggestion that various *Bifidobacteria* and *Lactobacillus* species might influence mood in humans as well as rodents. In one trial, healthy people given a blend of such probiotics for 30 days were found to fare better in questionnaires probing anxiety, depression and stress than those who were given a placebo. But that doesn't mean we should be stocking our shelves with probiotics just yet. "For me, taking a probiotic is like saying I'll take a drug," says Prof. Cryan. "You might take a statin for cardio-vascular disease, but you wouldn't →

Small but mighty

Most bacteria are just a few micrometres in length – smaller than red blood cells

Bacteria are typically made up of just a single cell each, but these cells are very different to those that make up the human body. Bacterial cells do not have a membrane-bound nucleus. And besides chromosomal DNA, bacteria can have 'extra' little loops of DNA called plasmids. They also lack membrane-bound organelles such as mitochondria – the 'batteries' of our own cells – and nearly all bacteria cells possess a cell wall.

Some bacteria are able to harness light energy, while others make use of chemical reactions involving organic or inorganic compounds to fuel processes in the cell. Bacterial cells are typically just a few micrometres (μm) in length. *Lactobacillus* cells, for example, are around 3μm long. Our own cells, however, can vary in size quite widely. Red blood cells are typically 7μm in diameter. And ova, the largest human cells, can reach 120μm – roughly the width of a human hair.



Lactobacillus 3μm

Red blood cell 7μm

Human hair 120μm

1 μm = 1 micrometre = 1 millionth of a metre

MARTIN OEGGERLI

Intestinal bacteria help us to digest food and absorb nutrients

Gut feeling

Probiotics and prebiotics have alleged health benefits for us. But what are the differences between them?

Prebiotics are substances that we cannot digest, but are believed to promote 'good' bacteria in the gut. Prebiotics occur naturally in some foods and include carbohydrates, such as fructo-oligosaccharides, galacto-oligosaccharides and inulin.

Probiotics are live microbes that are thought to bring a health benefit. They are often ingested through liquid drinks, yoghurts or tablets. Some of the most studied probiotics are of the genera *Lactobacillus* and *Bifidobacterium*.

The health benefits of probiotics are specific to each strain and different commercial products contain different bacteria strains.

Commercial products in the EU are banned from using the label 'probiotics' as the health claims of such products have not been approved, but manufacturers are allowed to list the strain of bacteria included.

According to market researchers BCC Research, the global market for such products is expected to be worth around $36.7bn (£24bn) by 2018.

ALAMY

take it if you had depression – that's where we are with probiotics. We need to get more precise about which bacteria are doing what and why."

Of mice and men

While it is still early days, Prof. Cryan foresees a future of 'psychobiotics' – probiotics that could be prescribed to help treat people who are suffering from mental health conditions. Taking substances that promote the presence of 'good' gut bacteria, known as prebiotics, might also prove beneficial.

"I think down the road there is a lot of hope that people will, in addition to getting their blood taken when they go to their GP, also get a quick snapshot of what's going on in their microbiome," states Prof. Cryan. That, he believes, could lead to the prescription of probiotics, perhaps in parallel to various other treatments.

Dr. Foster is cautious. "Until we have some evidence that the microbiome is different in different mental health disorders – and how it is different – we can't really talk about how relevant what we are learning in the mouse is to people," she explains. There are significant differences between mice and men, including the fact that the human brain boasts a very different prefrontal cortex to that of a rodent. This will affect the ways in which the gut microbiota may function. "If your microbiota send a signal to lower lying brain areas, the mouse doesn't have much to compensate for that and it exhibits a particular behaviour," says Prof. Mayer. "In humans, these layers of prefrontal cortex can compensate and make up for it."

Prof. John Cryan studies the effects microbes have on our physiology

CLARE KEOGH, UNIVERSITY COLLEGE CORK

As Prof. Mayer has found, gut bacteria do appear to have some impact on the human brain. In one small study funded by dairy product manufacturer Danone, Prof. Mayer's team split a cohort of healthy women into three groups. One group was given a probiotic yoghurt, one a probiotic-free dairy product and the other nothing at all. The women's brains were scanned using functional Magnetic Resonance Imaging (fMRI) at the start of the experiment, then again after four weeks of taking the intervention. The study found that there were differences between the three groups in the connectivity of various brain regions when resting. But when the women were asked to match images of angry or frightened faces to similar pictures, the probiotic group showed a decrease in the activity of brain regions involved in emotion and sensation. It was a surprise. "I didn't expect it," says Prof. Mayer candidly. "I was a sceptic in the beginning of all these animal studies. They just seemed too outlandish – it seemed like it just didn't fit into our paradigm of brain-gut interactions." But, he points out, there's more to do. "It would be nice to repeat a study like the one we did, possibly in a population with anxiety so that we can determine [whether] these brain changes seen with the probiotic are also correlated with subjective changes in anxiety."

"The probiotic group showed a decrease in the activity of brain regions involved in emotion and sensation"

Just how big an influence microbes have over our mood has yet to be determined, but Prof. Cryan believes we might be surprised. "It's worth considering that they are the master puppeteers," he says. ■

THERE'S NO PLACE LIKE HOME

Microbes don't just affect our mood (see page 26), they're also key to keeping us healthy. **TOM IRELAND** reveals a surprising picture of the bugs found around the home, and how each family has its own personal zoo of bacteria

Human beings are increasingly seen by scientists as walking microbial ecosystems. Our bodies contain about three times as many bacterial cells as human ones, and we each deposit a unique blend of bacterial cells everywhere we go.

Microbiologists are only just beginning to understand how the trillions of organisms that live in and on our bodies affect our digestion, immune response and behaviour.

An emerging area of study is looking at how the bacteria that we (and those that we live with) deposit around us interact with the buildings we inhabit.

Researchers from the Home Microbiome Project recently assessed the microbial communities associated with seven families and their homes over six weeks, including three families that moved to a new house. They found that we quickly spread our own 'microbial signature' throughout the places we live. By sequencing the DNA of bacteria in the home, the researchers were able to create a picture of the genetic diversity of microbes in each environment – its 'microbiome' – and compare how genetically similar bacteria were to those found elsewhere.

The bacterial flora of each household was so unique that researchers were able to accurately match individuals to their dwellings – even when their 'home' was in fact a hotel room they'd only recently moved into. Not only did all the houses contain →

ILLUSTRATION: ROBIN BOYDEN

very different bacteria from each other, the study also showed that when families moved, their microbial signature quickly re-established itself in the new location.

The reason our bacteria dominate the places we live is simply because there are few other routes by which bacteria enter those buildings. "Almost all of the bacteria in the home can be traced back to the inhabitants," says Simon Lax, a graduate student in the Department of Ecology and Evolution at the University of Chicago, and co-author of the study. "If you have humans constantly coming into a home, then they are the most common source of bacteria."

Some studies suggest people now spend between 22 and 23 hours a day indoors – and nearly 70 per cent of that time is spent in our homes. All that time at home might make you want to clean up. But obsessive cleaners might want to re-think their strategy – the study suggests that the more people potter around the house cleaning, the more bacteria they deposit. The best thing they could do to reduce the amount of microbes in their homes is not be there, says Lax: "When you think of what people's homes are made from, they are mostly relatively new materials that bacteria haven't evolved to live and thrive on. These homes would normally have quite a low bacterial biomass until someone comes in."

It's a family affair

Who we live with and what we do also plays a key role in determining which bacteria take up residence in our homes. The study found that people sharing a home are more microbially similar to each other than those not sharing a home. The hands of young couples and couples with children were especially similar, thanks to regular physical contact. But there's one area of the body where we are each more individual – the nose.

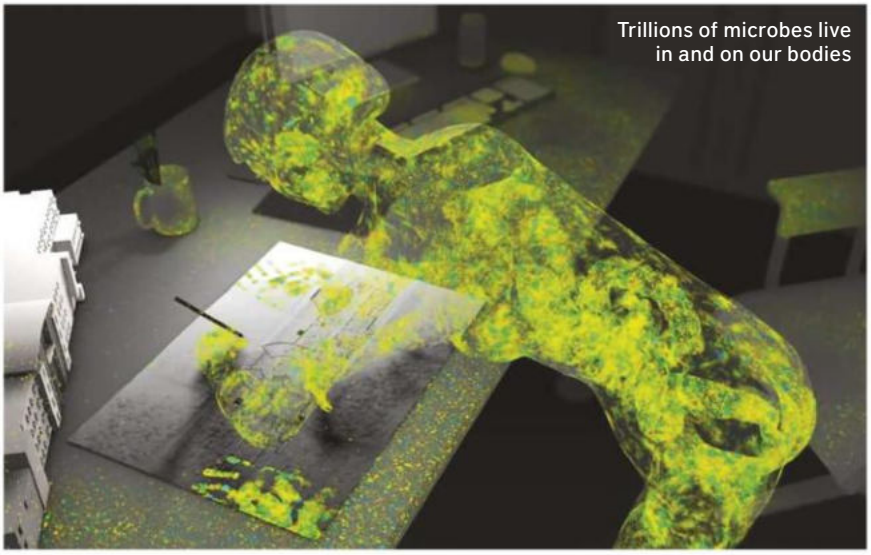
"The nose is a fairly stable environment that may be more unique to each person," says Lax. "But for places like the hand, it really comes down to what you've been in contact with, what you do for a living, who you've met, and whether you live in the country or in the city. It's more of a lifestyle thing than anything genetic."

ILLUSTRATION: ROBIN BOYDEN

Obsessive cleaners might want to re-think their strategy: the study suggests that the more people potter around the house cleaning, the more bacteria they deposit

Although the bacteria found on people and their homes were always highly correlated, houses were not necessarily closely matched with the bacteria of their pet. The presence of a pet does, however, hugely expand the diversity of bacteria found in a home. Samples from homes with pets contained more proteobacteria, a class of microbe that contains many well-known pathogens including Salmonella and *E. coli*. While that may sound like a bad thing, the more we understand microbial diversity the more we find that it helps us in more ways than it harms us. Exposure to varied bacteria at a young age is important for the development of a healthy immune system, for instance.

"It's not really a case of one house being more unhygienic than the other," says Lax. "But what we know isn't good for babies and young children is only experiencing the microbiome of their own environment and the bacteria of their parents," he says. It's a bewildering concept – not only that we are covered head to toe in this strange microbial mixture, but that it might actually be a vital part of a growing family's health.



Trillions of microbes live in and on our bodies

BIOLOGY & BUILT ENVIRONMENT CENTER/UNIVERSITY OF OREGON/CAMERON SLAYDEN/COSMOCYTE

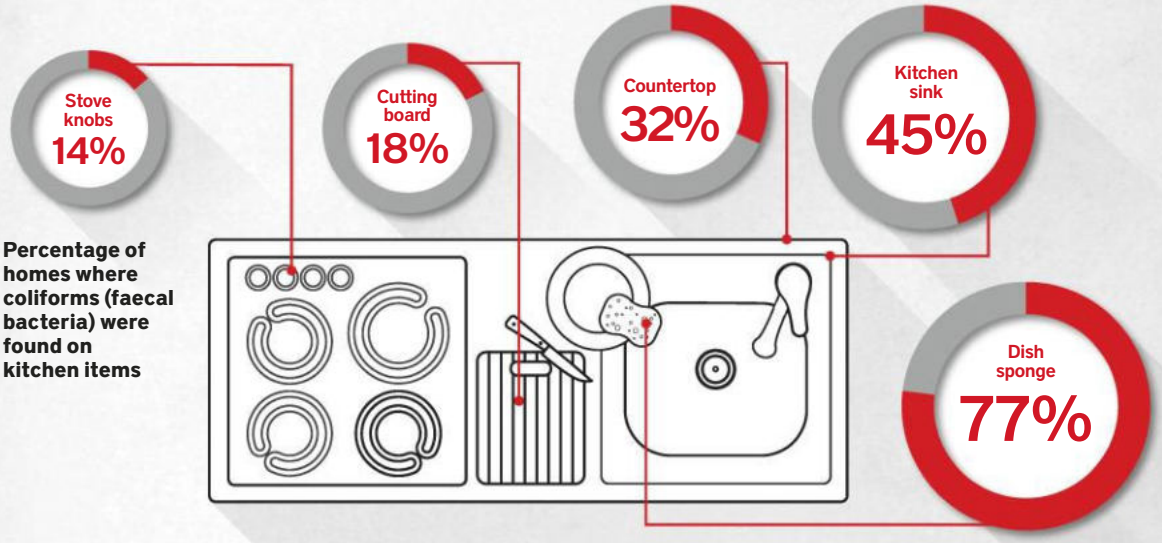
A new understanding

The Home Microbiome Project is one of the studies to treat families, their microbes, and their homes as complex interacting ecosystems. Research has traditionally focused on where and for how long bacteria survive in the home, and also how to eradicate them. This new approach may contribute towards a fuller understanding of what a healthy home is – for example, what levels of bacteria can help develop a healthy immune system and what levels may constitute a health hazard. And it's not just physical health where bacteria can do good – the

Microbial hotspots in our homes

Our perception of hygiene often bears little relation to the reality of what microbes live where. Here's a rundown of some of the most colonised areas

Percentage of homes where coliforms (faecal bacteria) were found on kitchen items



3x

more bacteria are in the human digestive tract than there are cells in the human body

1.5ml of human saliva has 150 million bacteria – equivalent to the amount found in one litre of Thames water

An iPad may house 30 times more *Staphylococcus aureus*, the bacteria that can cause MRSA, than a toilet seat

One sneeze can increase the amount of *Staphylococcus aureus* in the air nearly fivefold

1,000,000,000,000

bacteria are harboured on human skin, which is **3 per cent** of the total number of cells that make up the human body

MICROORGANISMS ON HOUSEHOLD OBJECTS

The microorganisms found included *Staphylococcus aureus*, yeasts, moulds, and coliforms such as *E. coli* and Salmonella, as measured by the US National Sanitation Foundation

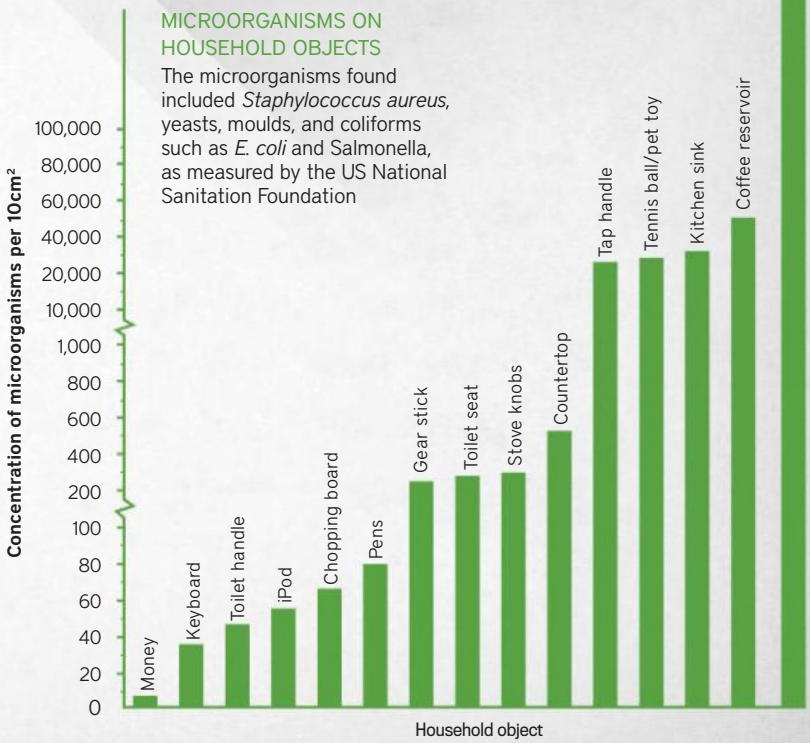


ILLUSTRATION: ROBIN BOYDEN

Microbiome Institute at the University of Cork, in Ireland, have linked bacteria to reduced stress and better memory (see page 57).

Back at the Home Microbiome Project, the team's next aim is to scale up its investigation and survey the microbiome of hospitals. "We are now taking this approach and applying it to environments where the health implications are much higher," says Lax. "We've seen hospitals with identical layouts and identical cleaning methods, so it can only be the different people that affect the bacterial samples found there. And in a hospital environment, there really are such things as good and bad microbiomes."

As our understanding shifts from a fear of all bacteria to recognising their role in ecosystems, our approach to tackling infection is likely to change. Attempts to simply wipe bacteria away seem increasingly futile. Indeed, some bioscience companies believe sprays containing 'good bacteria' may be a more effective way of preventing dangerous human pathogens from taking hold in certain places.

> Only experiencing the microbiome of their own environment and the bacteria of their parents isn't good for babies
>
> *Simon Lax, Department of Ecology and Evolution at the University of Chicago*

More projects measuring the impact of microbes in the built environment are planned. Some even involve architects, who hope that future buildings can be built to encourage a healthy microbiome, or species that absorb pollutants.

For Lax, the results of his study have opened his eyes to the unseen microbial mark humans make wherever they go. "I'm not grossed out by it, but it definitely makes you think. Am I leaving my signature behind when I visit this house? Am I changing what bacteria live here?"

In time, maybe we will all come to see our house's bacteria not as dirty intruders, but welcome guests – perhaps even tiny members of our extended family. On the sofa tonight, sit back and relax in the knowledge that it's just you, your family, and a trillion bacteria that seem to enjoy your company in particular.

It's true what they say – there really is no place like home. ■

EXERCISE
A cure for all ills

Our ability to run, ride, swim, and play sport offers us a wealth of health benefits. **ROB KEMP** looks at how it can combat many physical and psychological ailments

GETTY IMAGES

Perhaps the best advertisement for the natural 'cures' exercise can provide comes in the shape of the warnings we get if we abstain from regularly breaking into a fitness-focused sweat.

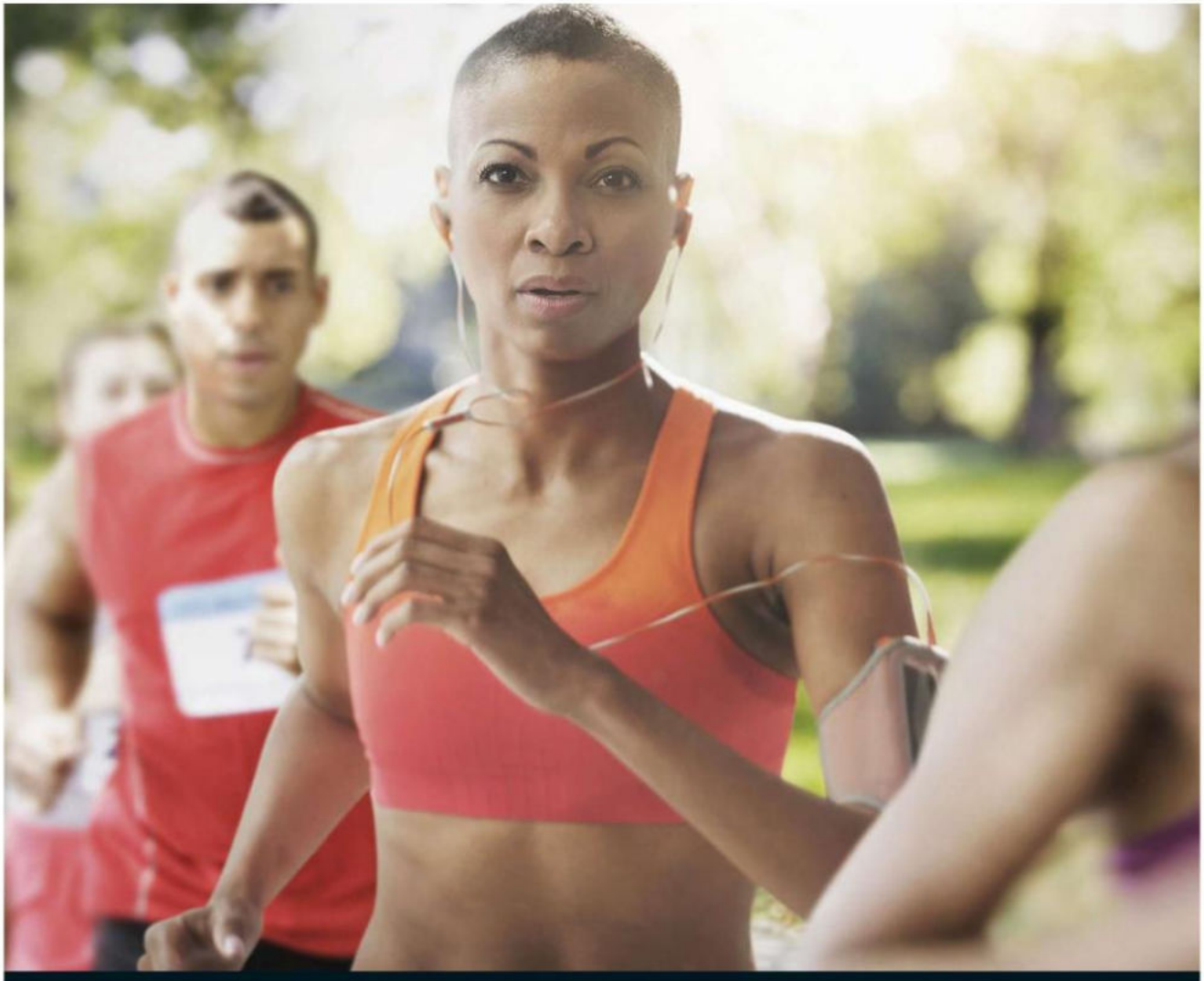
Depression, obesity, lethargy, heart disease, insomnia, dangerously high levels of fat around the internal organs, impotence, breathing difficulties, poor concentration, low self-esteem and a weakened immunity to illness are just some of the conditions from which science says a regular workout can save us.

As an increasingly convenience-focused, sedentary lifestyle becomes the norm for too many, the need to get active has never been greater.

But Professor John Brewer, Head of the School of Sport, Health and Applied Science at St Mary's University in London, warns: "Listen to your body. Exercise is about adaptation, you put your body through stresses that it has to adjust to. As a result, rest and recovery are as vital to ensuring exercise is effective in the long term. Always seek out expert advice or talk with your doctor."

The key is to get the right balance – pushing your body to achieve the best results from the natural benefits exercise has to offer, while also giving it time to recover.

So what exactly will exercise do to cure your ills? And how? Find out on the next few pages...



Hit the highs

Running has been shown to release endorphins and aid with sleep

Beyond the positive influence exercise has upon the body's strength, fat reduction and overall function, exercise can trigger a series of chemical reactions that influence the body's hormonal response and boost the brain in many ways.

"One of the most widely acknowledged benefits is the 'runner's high'," explains Dr. Peter Herbert, a physiologist at the University of Wales Trinity Saint David. Back in the 1990s, researchers began to identify links between exercise and feelings of euphoria that stem from the release of natural opiates. "The 'runner's high' as we now know it stems from the creation in the body of endorphins, designed to ease pain in the body."

Although the 'sweet spot' for endorphin release is commonly said to be a comfortable-to-hard effort run, Herbert points out that many forms of exercise can trigger the 'high'. Research from Oxford University even found that simply exercising in groups raised the release of endorphins quicker for some than exercising alone.

"These endorphins are opoid neuropeptides – chemicals which numb pain, like opoids such as morphine or codeine," adds Dr. Herbert. As a result, exercise and the release of endorphin substances, such as endocannabinoids, may contribute to pain relief and relaxation.

And for those of you who are reading this in bed and not feeling sleepy, the next time you're struggling to get a decent night's sleep, it's worth knowing that donning your running shoes can make a huge difference. A number of studies confirm that sleep quality for insomniacs can be made a whole lot better with more exercise.

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Keep your heart healthy

Walk a minimum of 150 minutes a week to lower your risk of heart disease

As the body adapts to the demands exercise puts upon it, other health remedies become apparent.

Hypertension, or high blood pressure issues, can be combated through exercise. "Aerobic activity, even at moderate levels through regular walking, has been shown to trigger vascular adaptations, developing the capillaries, easing constrictions in peripheral circulation, and reducing the pressure," says Professor John Brewer, Head of the School of Sport, Health and Applied Science at St. Mary's University in London.

It's just one example of how exercise can be a significant contributor to cutting cardiovascular disease, which is one of the leading causes of death in the UK.

Getting at least 150 minutes a week of moderate-intensity aerobic activity can lower your risk of heart disease, reports the American Heart Association – while also improving your cholesterol levels.

Defend against depression

Exercise stimulates the production of mood-lifting serotonin

Studies reveal that exercise can reduce stress and have longer term effects on one's mood.

Over time, the hormonal response that exercise triggers is an effective treatment for depression. Research published in the *Journal of Psychiatry and Neuroscience* shows raised levels of tryptophan in athletes, especially in endurance runners – that is an indicator of raised levels of a mood-elevating neurotransmitter known as serotonin.

Psychology specialists at the University of Essex have also recorded significant improvements in self-esteem and mood, along with fewer incidents of depression among people who exercise outdoors.

"For many people exercise and the positive impact it has upon the way you look can also be a remedy for melancholy," says Professor John Brewer, Head of the School of Sport, Health and Applied Science at St. Mary's University in London. "Studies confirm it can contribute to curing low self-esteem, especially among those who work out with a team."

A polarized light micrograph (PLM) of the neurotransmitter serotonin

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Beat brittle bones

Regular bone and muscle strengthening exercise slows bone density loss

"The ageing process can take its toll on your bones, joints and muscles," explains physiologist Dr. Herbert.

Medical conditions such as arthritis of the joints and a natural depletion of bone density put us at greater risk of serious injury if we have accidents such as falls.

But simply taking part in routine bone and muscle-strengthening aerobic exercise can slow the loss of bone density as we age. For age-related health issues, such as a hip fracture, making sure you're doing moderately intense walking for 120 to 300 minutes a week will cut your risk.

Exercise has been shown to help in the prevention of arthritis and other conditions affecting the joints, such as gout and osteoarthritis. Research also shows low-impact aerobic activity can help those suffering with joint conditions to better manage their pain.

Keep it up

Sexual function, and problems such as impotence, may be given a helping hand by regular workouts

Research from the US and Nigeria shows that for men with erectile dysfunction, aerobic exercise can provide a natural alternative to the little blue pills.

"Certainly major components in the causes of impotence can be physical – with a sedentary lifestyle often cited as a risk factor in it occuring," explains Professor John Brewer, Head of the School of Sport, Health and Applied Science at St. Mary's University in London.

Psychological issues, such as low self-esteem and high levels of stress, are also given as reasons for impotence – something exercise can also help.

ALAMY / GETTY IMAGES

Exercise may reduce the risk of colon cancer by as much as 25 per cent

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Combat disease

Exercise can help in the fight against cancer and diabetes

Running, walking, cycling or playing an active role in team sports can provide a natural medicine to ward off type 2 diabetes and metabolic syndrome – a condition with symptoms that may include too much fat around the waist, high blood pressure, low HDL (good) cholesterol, high triglycerides or high blood sugar.

Exercising at a moderate intensity for 120 to 150 minutes a week has been shown to reduce these risk factors in a series of studies.

Research also reveals how exercise is becoming key to reducing the risk of some cancers. Regular physical activity was found to reduce the risk of breast cancer in women by 12 per cent, while the impact it can have on reducing colon cancer in men and women may be as high as 25 per cent.

Although studies continue, there's some suggestion that a person's risk of endometrial cancer and lung cancer may be lower if they get regular physical activity when compared to people who are not active.

Fend off fat

Exercise burns calories, which inevitably aids in weight loss, but running also stems the production of the 'hunger hormone'

One of the most apparent remedies exercise can bring is around weight loss and weight management.

A whole host of research, including studies from the *Journal of Applied Physiology*, highlight how a combination of aerobic exercise and resistance training (using weights, machines or bodyweight to train muscles) can have a positive impact on fat levels and waist circumference among overweight subjects. Resistance training has been shown to contribute to the development of muscle mass, changes in body composition and fat reduction.

Just moderate intensity aerobic activity, such as walking, can make serious in-roads into weight loss, too. In one of the most recently published studies, from the London School of Economics, researchers found that brisk walking – when done regularly enough – was as good as gym training for those looking to lose or maintain their weight. Interestingly, a study of 50,000 patients between 1999 and 2012 found that those who walked regularly had lower body mass indexes (BMIs) than patients who took part in high-intensity exercise.

Although the results aren't and shouldn't be immediate, regular exercise in conjunction with a managed, balanced diet has been shown to be the safest, more effective means of shedding fat and keeping it off.

"The body fuels exercise with energy drawn from within – from blood sugars and body fat," explains Professor John Brewer, Head of the School of Sport, Health and Applied Science at St. Mary's University in London. "In order to lose weight and reduce body fat levels you need to create a calorie deficit – burning more calories than you consume. To burn off 2lbs of fat costs around 8,000-9,000 calories."

Running a marathon will only hit around a third of that figure. By creating a daily deficit of 500 calories, through heart-rate raising exercise and controlling your calorie intake, you can make serious in-roads into your body fat percentages.

Researchers from the University of Western Australia have also found that running contributed to weight control by regulating appetite. Runners performing interval sessions in a trial reported fewer cravings for snacks as a result of the exercise regime curtailing the production of ghrelin, nicknamed the 'hunger hormone'.

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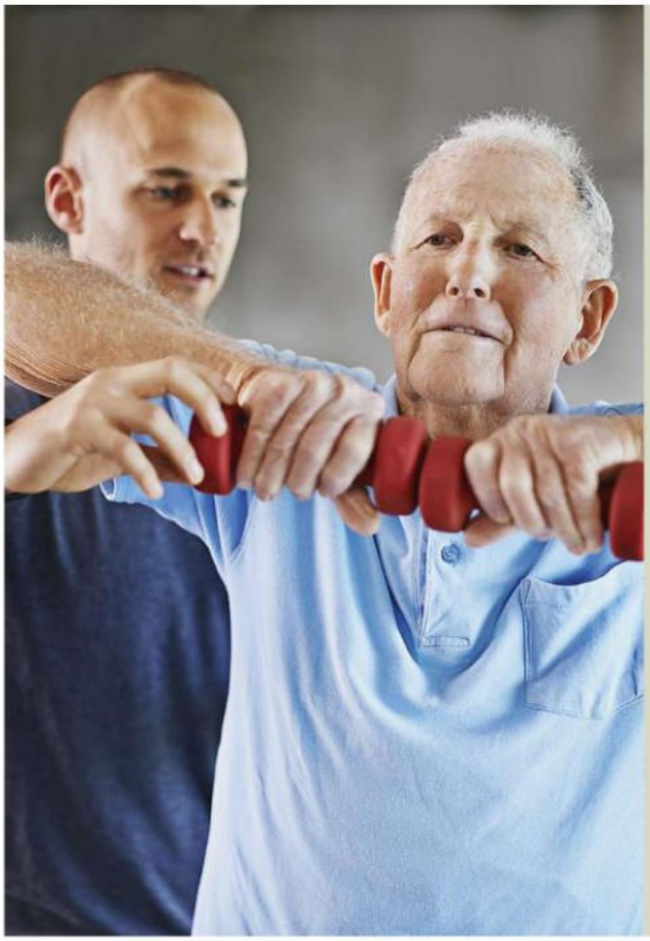

Stay sharp

Exercise keeps us mentally fit too

Aerobic exercise, or a combination of aerobic and muscle-strengthening activities, three to five times a week for 30 to 60 minutes can help maintain learning and keep judgement skills sharp. Meanwhile, natural brain reactions to exercise have been shown to protect us from forgetfulness, and improve problem solving and thought processes.

Recent research even suggests that exercise throughout one's lifetime can play a major role in battling the onset of age-related ailments, such as dementia. Several studies, including one from Japan published in the *International Journal of Sports Medicine*, and another presented at the 2015 Alzheimer's Association International Conference, found that both regular aerobic exercise and some forms of resistance training improved hippocampus-related memory, and slowed down cognitive decline.

A study from the University of Montreal noted that those of us who use the weight room to build muscle may be giving the brain a lift, too. The study suggests that the raised levels of growth factor 1 (IGF-1) caused by resistance training helps in neuron (brain cell) growth and longevity.

Natural exercise supplements

Dr. Emma Derbyshire, an expert in nutritional physiology at Manchester Metropolitan University, reveals natural exercise supplements that can make your workout more effective

CAFFEINE

A natural stimulant found in tea, coffee, cocoa and colas, caffeine has long been known to enhance performance. Lower doses of caffeine (about 200mg or <3mg per kg body mass) are thought to help improve alertness, mood and concentration during and after exercise, with few if any adverse side effects.

CHERRY JUICE

Cherries are a great source of antioxidants, including vitamins A and C, as well as anthocyanins – red, blue and purple pigments which have potent antioxidant properties. Drinking cherry juice, which contains these components, may help to reduce inflammation and ease muscle soreness after exercise.

RED MEAT

(Iron)

Lean red meat is an important source of essential nutrients, including iron, zinc and energy-yielding B-vitamins. Female endurance runners in particular are vulnerable to iron deficiencies, and so should try to include lean red meat regularly within their diets.

PROTEIN

(Essential amino acids)

Protein is needed during exercise to offset muscle wasting, which can occur when protein intakes are inadequate. High-quality protein, such as that found in fish or red meat, can help to maintain muscle size and strength, particularly when combined with resistance training. ■

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A HELPING HAND

Months of queasiness, topped off by a 24-hour (plus) labour. Many mums have had to deal with the hardships of pregnancy, followed by a harrowing birth. **ZOE CORMIER** investigates natural ways to make the experience easier

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Research suggests that water birth might facilitate women to have a birth without interventions, such as an epidural

Ethel Burns, Senior Lecturer in Midwifery at Oxford Brookes University

Just imagine pushing an object the size of a watermelon through the most sensitive part of your body. Labour could take hours, even days. Sound terrifying? For many women – and their partners – the anticipation of childbirth can be scary. This fear can make the experience more painful by enhancing anxiety and muscle tension. It's a complex interaction between the mind and body during an incredibly intense experience.

"In mainstream medical treatment, pregnant women tend to have quick check ups that examine the physical state of them and their baby, but don't usually prepare them for the actual event – physically and mentally," says Emily Koehler, a so-called 'doula', who gives support and advice to women during pregnancy and birth. "Traditionally, pregnant women are treated with white gloves, so they go into labour thinking they're fragile and not appreciating how strong they can be."

Most practitioners who teach 'alternative' methods to overcome labour pain, which don't involve epidurals or other drugs, advocate finding ways to quell adrenaline and fear with a variety of tactics. From hypnobirth to birthing pools, they are increasingly popular, and a far cry from women simply lying flat on their backs in front of doctors wielding forceps. But do they work?

Ancient practices

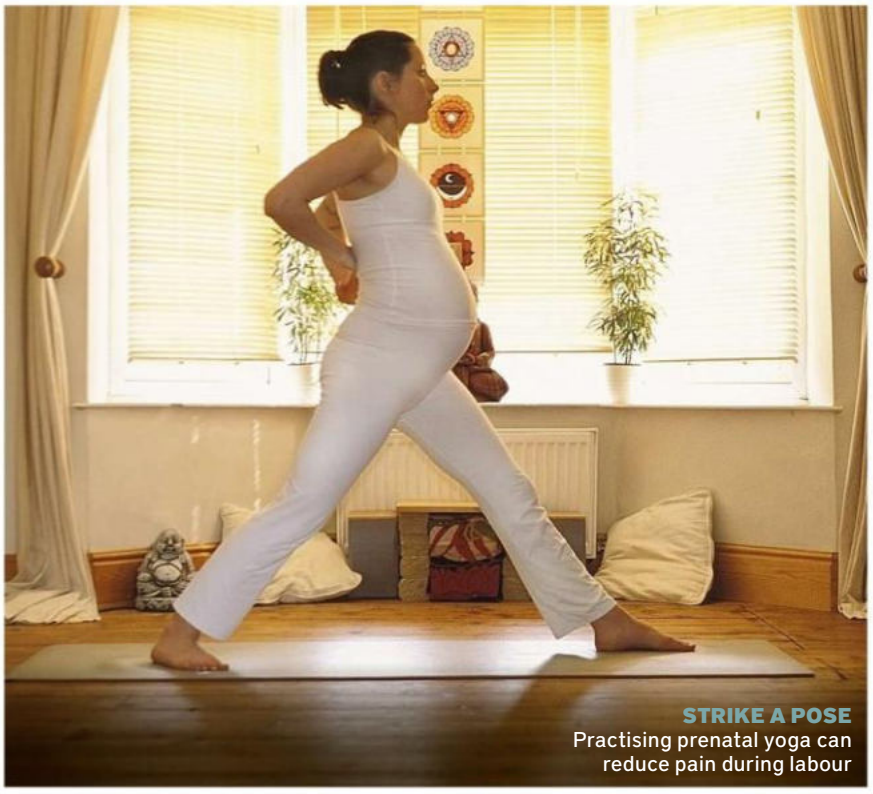
Many mums-in-waiting prepare for battle by striking the warrior pose, and other positions at prenatal yoga classes. This ancient practice has been shown to have a number of health benefits (see page 80), and a recent study by Japanese researchers found that prenatal yoga can help expectant mothers – reducing pelvic pain during birth by preparing the abdominal muscles for labour.

Of course, once it gets to the actual birth, muscle control becomes key. As labour kicks in, contracting certain muscles while relaxing others is a delicate tango between exertion and agony. Studies show pain is reduced during labour if a doula or birth partner massages the perineum (the region between the thighs and the pelvic diaphragm) or carries out acupressure, as shown by research published in the journal *Acta Obstetricia et Gynecologica*. But, others recommend more exotic techniques to limber yourself (and your baby) into the right position.

"One of my favourite tools is the 'rebozo'," says Nici Shipway, a mother and doula based in Toronto, Canada. This traditional South American shawl can be wrapped around the mother's belly to help open the hips, and give a relaxing cradling movement. "It's not only soothing for the mum, it helps move the baby into the right position."

Hot water

Riding out contractions – or giving birth entirely – in a shallow, warm pool is increasingly popular. Understandably so. Who doesn't enjoy chilling out in a hot bath at the end of a long day? So, for expectant



STRIKE A POSE
Practising prenatal yoga can reduce pain during labour

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WATER BABY
Birthing pools reduce the amount of drugs a mother needs during birth

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mums the psychological familiarity adds to the soothing qualities of the warm water, while the buoyancy helps with back and muscle pain.

"In the UK, birthing pool use during labour is now a mainstream practice," says Ethel Burns, Senior Lecturer in Midwifery at Oxford Brookes University, where water births are a standard treatment available in the NHS. "There is research to suggest that water birth might facilitate women to have a birth without interventions, such as an epidural."

Numerous randomised controlled trials and observational studies have shown that water births require less pharmacological relief, cause less tearing of the perineum, and provide greater maternal satisfaction and a higher chance of spontaneous birth. This has been proven – not only by Burns' own study of almost 8,000 women, which was published in the journal *Birth* in 2012 – but also in a study of more than 31,000 women from several countries, published in the *Journal of Midwifery and Women's Health* in 2014, which found the potential risks to be 'minimal'.

There are some fears that water birth could lead to infections in newborn babies, due to faecal matter spilling into the pool, but studies of water birth (at least, in developed countries) found no evidence of increased rates of infection. An Italian study, published in 2014, which looked at the experiences of more than 2,600 women found "clear medical advantages", including "significantly shorter labour duration, a net reduction in episiotomy rates; and a marked drop in requests for pain relievers."

But, inevitably, there are some possible risks. "Although observational studies haven't shown an association between water birth

→

and extensive perineal trauma, some clinicians express concern that it may predispose women to this outcome," says Burns, as shown by an American study published in the *Journal of Midwifery and Women's Health* in 2016. This is a real concern, but the jury is still out. As Burns points out: "One way to study this would be using randomised controlled trials."

Mind control

Another one of the most popular new treatments to ease pain is the widely-hyped 'hypnobirthing'. Often termed 'self-hypnosis', the technique involves a mixture of breathing exercises, visualisations and meditative practices to calm the body, and break the 'fear-tension-pain' cycle. In other words, mind over matter – if the mind can create anxiety, and anxiety can create pain, quelling mental noise can reduce pain.

Proponents of hypnobirthing claim that not only can it reduce pain and the use of pain-quenching epidurals, it can also shorten the duration of labour.

"It's about getting the mind out of the way, so that the body can do what it was designed to do," says Kate Johnson, who is based in the UK, and trained to become a professional hypnobirth therapist after using the technique during the birth of her first child. While Johnson never tells her clients that hypnobirthing guarantees a pain-free labour, she feels the training and knowledge will invariably help. "Having a greater understanding of how the body and hormones work, and how to use mental and physical tactics to reduce your own pain, can give you an enormous amount of confidence, which in itself will help make the experience more positive."

Many women have found that hypnobirthing dramatically helped with the pain. But many others report that the technique ceases to work in the final throes of labour.

"Not every woman is able to bypass their fears and biologies with the generic hypnobirthing programme," says Toronto-based Tanya Pillay, a certified hypnotist, who signed up for hypnobirthing for her own pregnancy five years ago. "While I appreciate the impetus to radically modify the mind, it's a lot to ask an expectant mother not to use the words 'pain' or 'contraction'. Referring to the sensations as 'discomfort' and 'surges' just wasn't realistic for me."

As with all new birthing techniques, some sing the praises of hypnobirthing, while others feel the hype is overblown. So what does the science say?

"The problem is that the labour ward is a difficult environment to relax in," says Soo Downe, Professor

RELAX AND BREATHE
A group learns hypnobirthing techniques in preparation for labour

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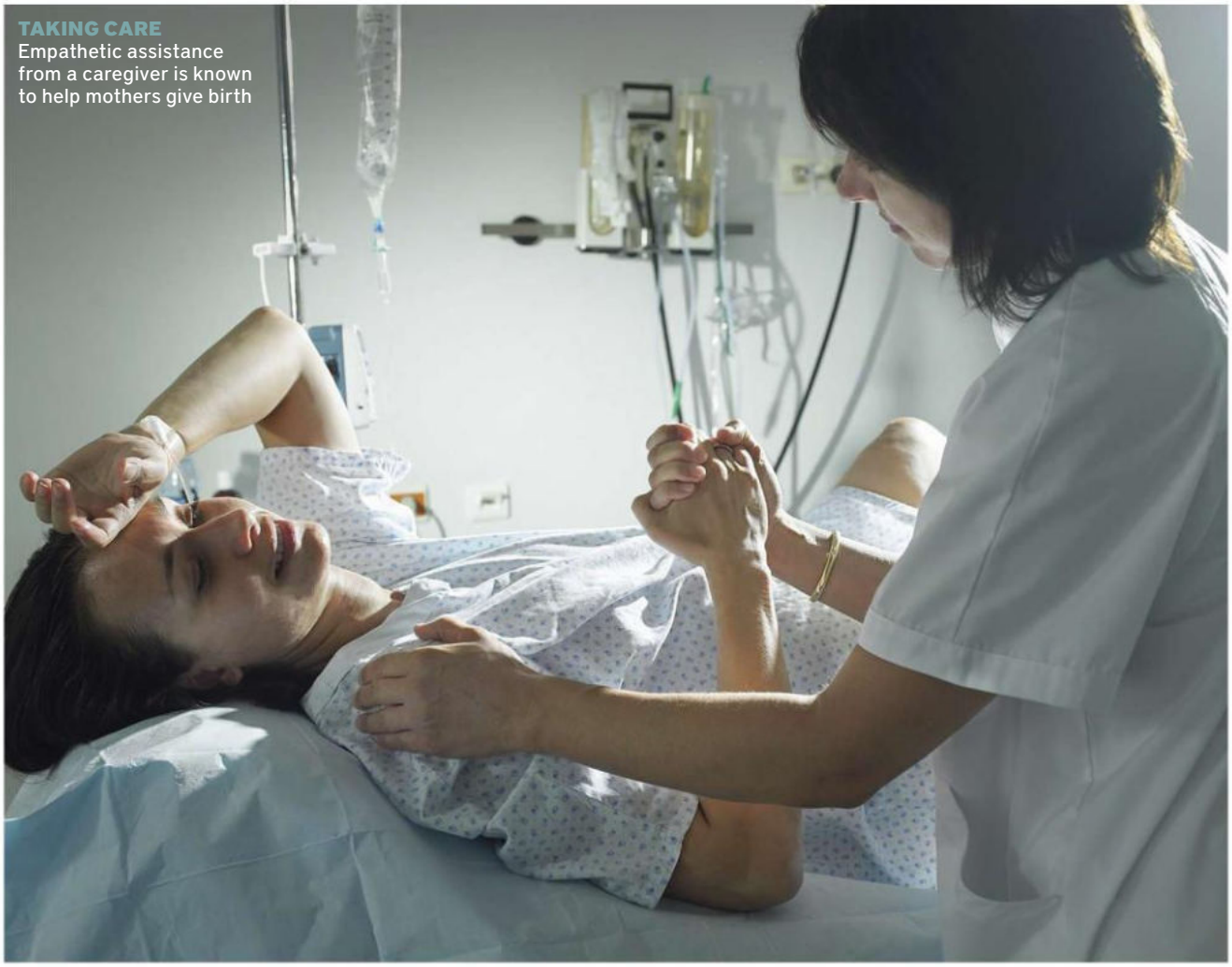
Mind over matter: if the mind can create anxiety, and anxiety can create pain, quelling mental noise can reduce pain



TAKING CARE
Empathetic assistance from a caregiver is known to help mothers give birth

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in Midwifery Studies at the University of Central Lancashire. "But there definitely is physiological evidence that hypnotherapy works."

Last year, Prof. Downe published the second largest randomised controlled trial of first-time mothers taught self-hypnosis or another standard therapy. The results, published in the *British Journal of Obstetrics and Gynaecology*, showed that of the 680 women involved in the trial, those given hypnobirthing training requested an epidural 27.9 per cent of the time, compared to 30.3 per cent of the control group – not a huge difference.

"For some women, hypnobirthing absolutely does work, but not for others," says Prof. Downe. "So in big population-based studies, you see a 'regression to the mean' – things even out to the middle and you don't see a huge effect at the big scale."

What's in a name

Most practitioners and researchers would agree – part of the problem in popular misunderstandings of the therapy lie not in the technique, but in the name. Hypnobirthing is not a form of 'hypnosis' as most of us would understand the term – nobody snaps their fingers and puts you into an otherworldly trance. Some think it should be called 'meditative birth', but even that label doesn't quite hit the mark.

For her part, Pillay thinks that there should be a genuine form of hypnotic therapy for birth pain. "If I were to write my own hypnosis programme for pregnancy, I would teach a birth partner how to be a hypnotist for the mother, with a customised series of hypnosis sessions to address the mother's personal fears, beliefs, values and preferences when applying metaphors and relaxation techniques."

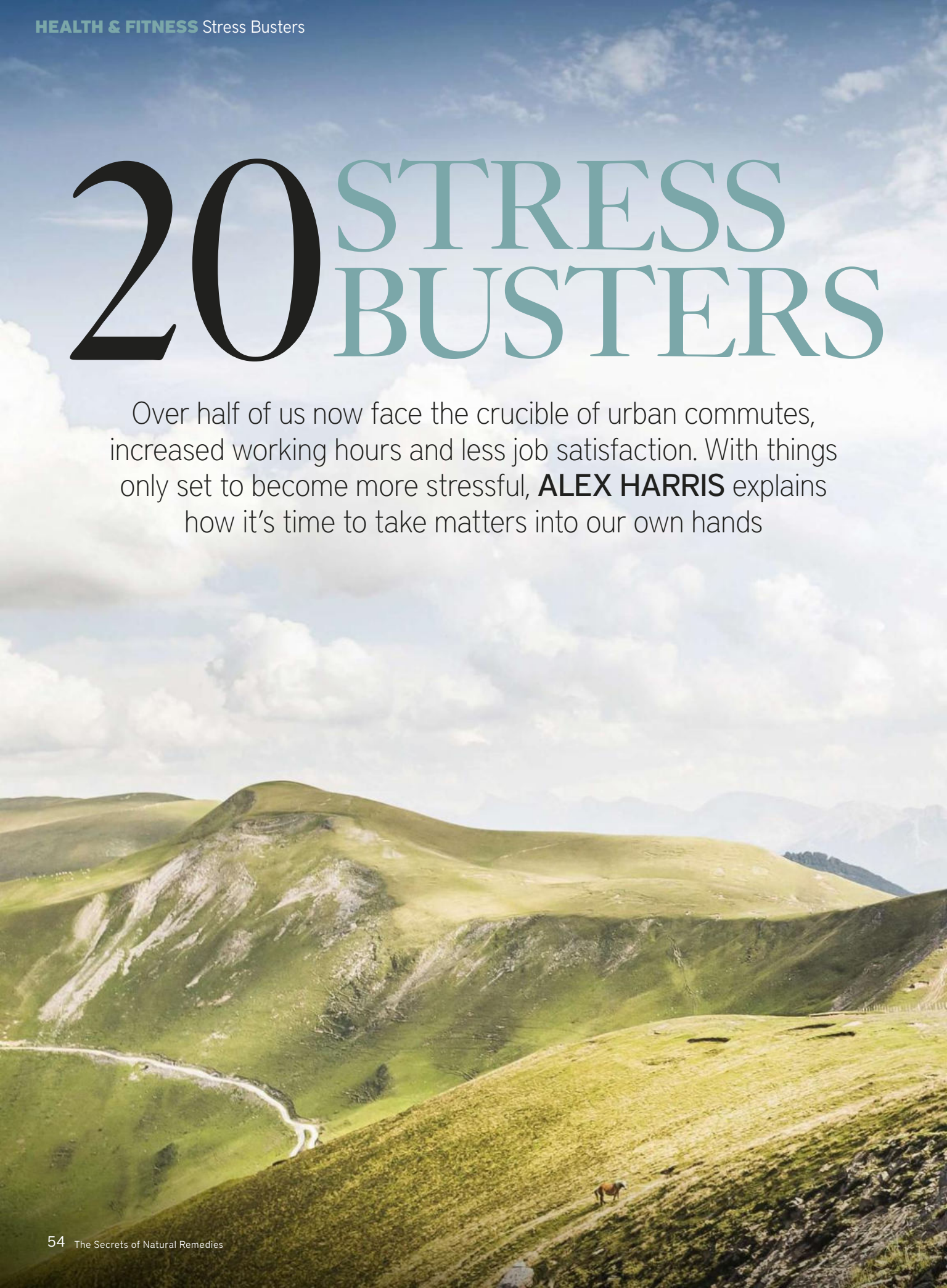
Which gets to the heart of all birth therapies – figuring out what works for the individual and customising all the tactics for each mother.

"Of all the therapies, the one we have the strongest evidence for is the continuity of the relationship the mother has with their caregiver," says Prof. Downe.

In other words: massages, mantras, mind control – it can all help, but in this most primal of acts, it's the human contact that is key. ■

20 STRESS BUSTERS

Over half of us now face the crucible of urban commutes, increased working hours and less job satisfaction. With things only set to become more stressful, **ALEX HARRIS** explains how it's time to take matters into our own hands



Stress is a delicate balancing act. On its tightrope wobbles your health and happiness – stay surefooted and it's a useful tool, but push too hard and stress can tip the balance and your body toward some ghastly diseases you definitely want to avoid. In chronic amounts, it flattens your mental faculties and increases inflammation. Around 44 per cent of Americans report feeling more stressed now than five years ago, while stress causes 75 per cent of all doctor visits, according to the US Centers for Disease Control and Prevention. On these negative effects the medical science community can agree.

But scientists are in less accord when it comes to the sure fit of so-called cures, of which you have probably seen, and indeed tried, many. In fact, the medical fraternity are utterly at odds – from acupuncture to supplements, expensive retreats to extensive books, contrasting studies abound, conflicting opinions more so. It's enough to give you a stress-induced migraine. Perhaps take some witch hazel for it. Actually, don't. Try these study-backed remedies instead. Stress is a subjective experience. To the men and women in white coats, these are objectively the best cures. →

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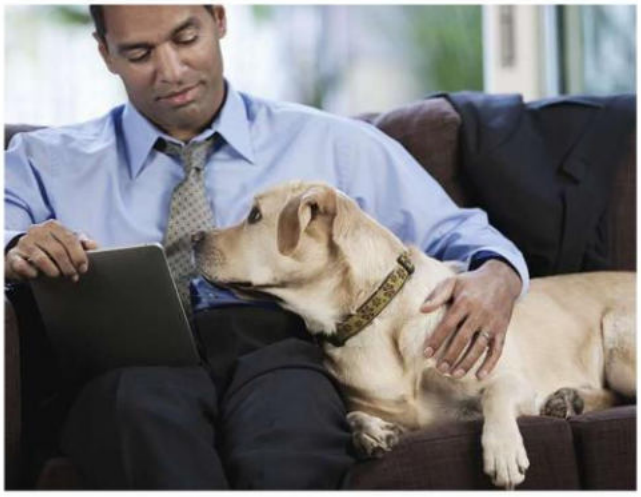

1 Get a pet

If work stress has you chewing the carpet, fret not – Fido has your back. Coming home to a faithful pet can de-stress you, curb blood pressure, and encourage the release of feel-good hormones, such as dopamine. That's according to research in the *Journal of Psychosomatic Research*. Even some law schools in America are bringing puppies in for 'cuddle days' to help students deal with the rigmarole of their final exams. Which is a smart rule, if you ask us.

2 Listen to some aural medicine

Stress can be a killer, but rock music can keep you off the stairway to heaven. In a recent study into the mental effects of head bangers, scientists at the University of Queensland, Australia, discovered that, contrary to accepted wisdom, heavy metal music can help you regulate emotions, such as anger and sadness. You don't have to go full emo – a 10-minute session is all it takes to get back out of black.

3 Take a hike

You don't need scientists to tell you that taking a walk in nature can help boost your mood and reduce negative feelings. But scientists at the University of Michigan, in the US, decided to prove it anyway. Their follow-up research was more interesting. They found that even looking at a picture of nature, or some trees or plants, can reduce cortisol and improve your mood, even more than a walk in an urban area. Google Images just became your new RX.

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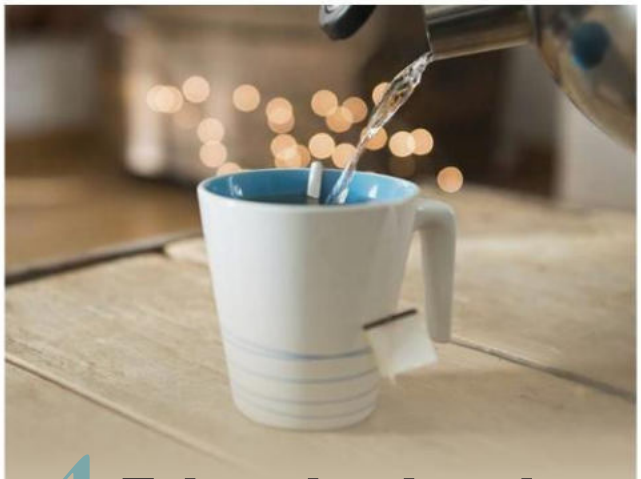
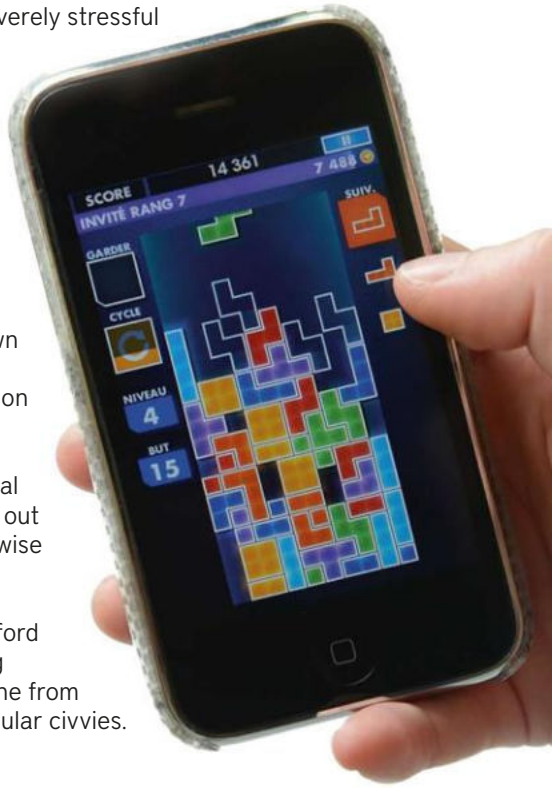


4 Take a tea break

Emulate the Brits and put the kettle on during times of difficulty. A study by City University in London found that, when placed in a stressful situation, test subjects denied a cup of tea showed a 25 per cent increase in anxiety, while those allowed a brew actually enjoyed a four per cent reduction. Aside from the benefits of the calming amino acid L-theanine, abundant in tea, the ritual of making the tea itself was found to be beneficial. Milk is optional.

5 Block out

After a severely stressful event, loading up Tetris® on your phone can keep the event from sticking in your memory, while also reducing the risk of it re-emerging as post-traumatic stress further down the line. That's because focusing on a highly engaging visual task can override your visual memory, blocking out what would otherwise force its way in permanently. The research from Oxford University is being utilised by everyone from the military to regular civvies. Best fall in line.

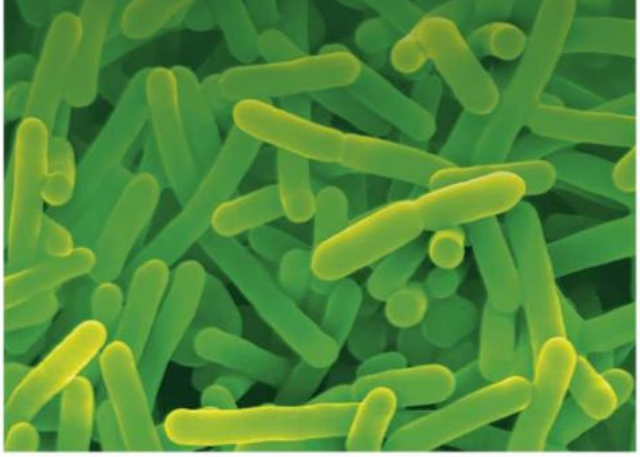


6 Play mind games

If Tetris® isn't your thing, more conventional video games might be. And that's no bad thing. A study co-authored by two graduate students (why aren't we surprised?) from the University of Wisconsin, US, showed that violent video games were a quick-fire solution to stress. Watch your dosage, though, as too much can increase the likelihood of you reacting aggressively. Short bursts on your daily commute are best, which a separate study at McGill University, Canada, found reduces the stress hormone cortisol by 17 per cent.

7 Get dirty with bugs

The so-called 'microbiome' of bacteria living inside each of us has been linked with everything from risk of disease to body composition. Now, bacteria-loving scientists are arguing the case for probiotics as a stress reliever. Having previously shown the strain *Bifidobacterium longum 1714* (try getting your mouth round that) to have a mitigating effect on anxiety, the Microbiome Institute at The University of Cork, Ireland, have now linked it to reduced stress and better memory.



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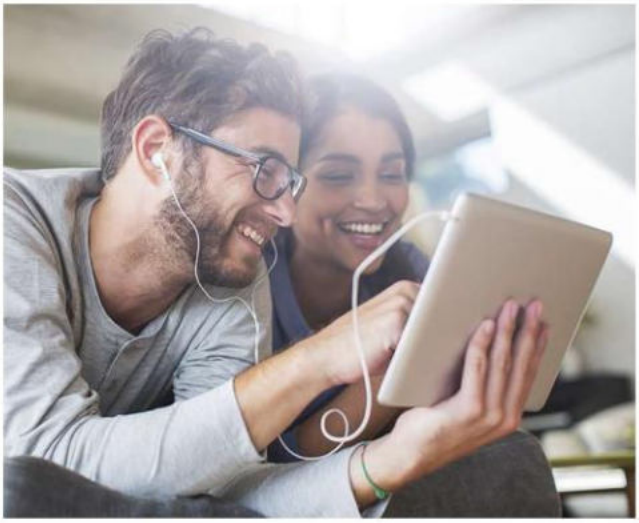
8 Enjoy a cup of coffee

If you prefer your hot drinks black with a crema floating on top, then don't change your habit just yet. Coffee could be a stress reliever. While an excess of caffeine will give you the jitters, an international team of researchers found that mice exposed to a certain amount of caffeine prevented adenosine receptors in the brain from reacting to stressful situations. So, if this also works for humans, your arabica could help combat stress during a tough day.

9 Keep your cool

The Scandinavians do a lot right when it comes to health – they eat lots of fish, walk everywhere, and ski like the ice is running out. But it turns out their best trait is their collective penchant for roasting away in a sauna. Published in the journal *JAMA Internal Medicine*, one particular paper reports some interesting findings. Sauna bathing is associated with a reduced risk of cardiovascular problems and all-cause mortality, meaning that a stress-induced heart attack will be off the menu if you bake yourself regularly.



10 Laugh it off

Perhaps you're a highbrow satire fan or maybe you just appreciate seeing someone fall over on YouTube. Either way, that fit of laughter will fortify your brain against stress. In the short term, it activates your stress response, then immediately calms you down, while bringing in more beneficial oxygen. In the long run, a regular guffaw has been shown to benefit your immune system. No joke.

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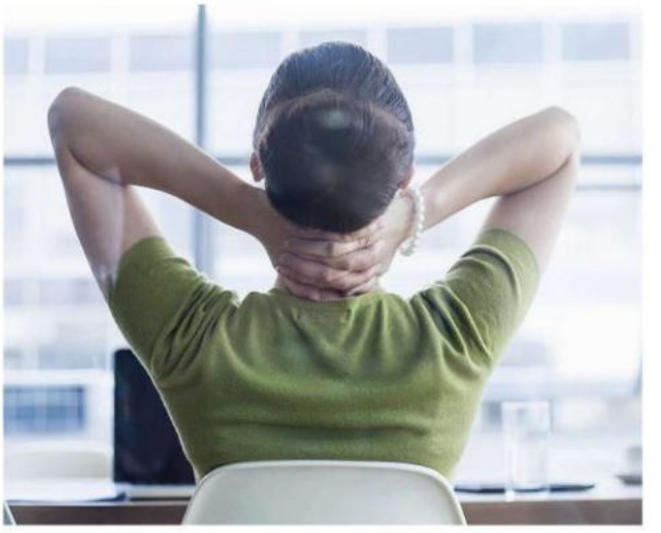
11 Get creative

Perhaps you approach those mindfulness colouring books with a drop of scepticism, but you can't argue with the recent findings of a San Francisco University study. The researchers found that, mindfulness aside, engaging in a creative pursuit out of work allows you to better deal with challenging times while actually improving your performance when back in the workplace. Pick up the guitar or dig out your paint brushes – it's all beneficial to your brain.

12 Take a breather

If your paperwork is piling up, just pause. One of the most well-established stress busters is actually internal. Harvard scientist Herbert Benson created the idea of the Relaxation Response, and a plethora of studies have backed up his notion. Slow, rhythmic breathing calms your nervous system, allows you to deal with mounting pressure, and can help bring your to-do list back down to Earth.



13 Help others

Despite the fact that we're focusing on looking after number one here, it pays to take others into consideration. That's according to a study published in *Clinical Psychological Science*, a journal of the Association for Psychological Science, which found that providing help to others – friends, acquaintances or even strangers – protects your mental health against the impact of daily stress. Something as trivial as holding open a door for a colleague can keep work pressure from getting in.

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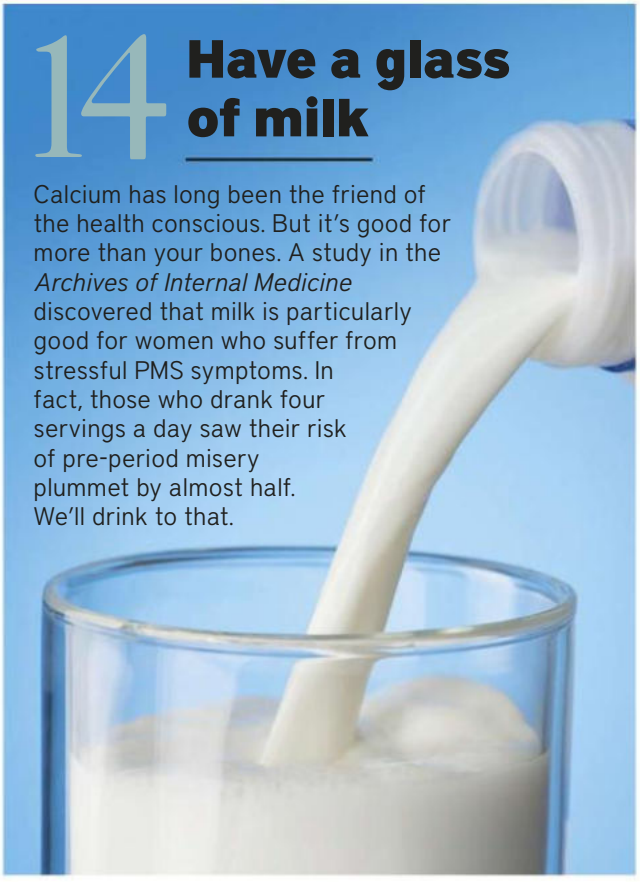
14 Have a glass of milk

Calcium has long been the friend of the health conscious. But it's good for more than your bones. A study in the *Archives of Internal Medicine* discovered that milk is particularly good for women who suffer from stressful PMS symptoms. In fact, those who drank four servings a day saw their risk of pre-period misery plummet by almost half. We'll drink to that.

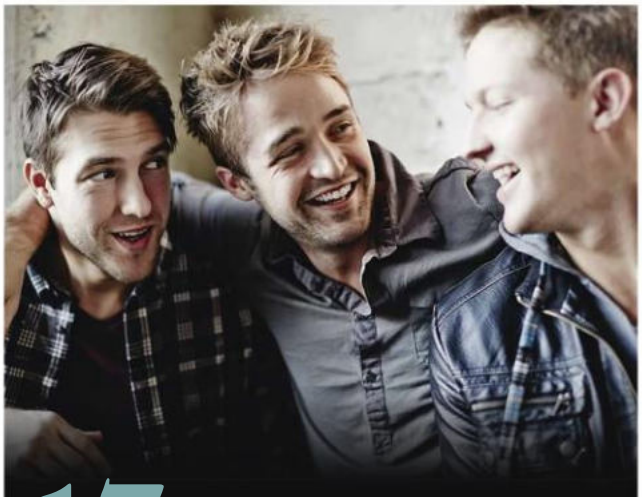


15 Do the washing up

Tough day at work? It's your turn to do the washing up. Extra chores might feel like self-flagellation after an onerous 9-5 at the office, but in fact the opposite is true. Florida State University scientists did a load of extra dishes (we're sure their partners were pleased) to determine whether the contemplative and uniquely tactile moment yielded any brain benefits. It turns out that getting up to your elbows in bubbles calms the mind and reduces stress hormones. It's also likely to induce boredom and a longing for Netflix, if you ask us.

16 Crack your noggin

The high-fat low-fat diet debate has been grabbing tabloid inches lately. While many nutritional scientists are at each other's throats about what should be going down them, there's one dietary truth everyone can digest – polyunsaturated fats from nuts are pretty good for you. So good, in fact, that a daily serving of walnuts can positively influence your blood pressure under stress. So say researchers at Penn State University, US, who tested the nuts and the nut oil on 22 people over six weeks before reaching these findings. The fact that walnuts look like tiny brains must be Nature trying to tell us something.



17 Find a bro

Depression and stress are so often uttered in the same sentence. And yet, while the former is wont to make you more insular and reclusive, the latter is actually totally different and might make you more social. A surprising study by German researchers found that stressed men in particular are more likely to seek out social bonding. Which is rather convenient, as quality bro time has been found to mitigate stress hormones.

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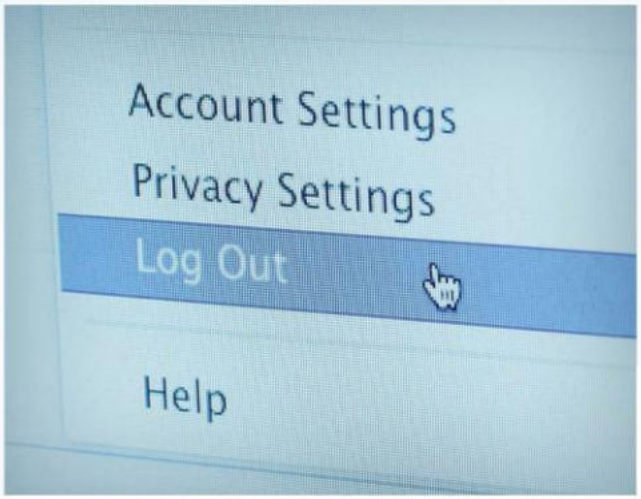
18 Clean up your act

Exercise beats stress. Not exactly groundbreaking stuff. More surprising, however, is the news that working up a sweat even when cleaning your bedroom can improve your mood and reduce feelings of depression. University College London researchers studied 20,000 people and found that taking part in sports cuts your risk of stress by a third, but vigorous housework is enough to reduce the risk to the tune of 20 per cent. The researchers say to aim for a solid 20 minutes and your mind will be as clear as the floor.



19 Ditch social media

Facebook might make you feel more connected but, in mental terms at least, the opposite is true. A study by the Happiness Research Institute in Copenhagen took a group of participants and had half eschew the social media site. After just a week, the offline half reported feeling happier, and less angry, lonely and depressed. What's more, people on Facebook were 55 per cent more likely to feel stressed. So take a break occasionally and your friends will thank you.

20 Give a hug

We're going to get all mushy for this last tip. It's accepted science that getting physical with a regular hug from a loved one releases oxytocin, which is why it's known as the hug hormone. But there's another biochemical argument for wrapping yourself around your housemate after a terrible day, which comes in the form of anandamide. This one is known as the bliss molecule on account of its link to happiness, and the fact that its release feels similar to the effects of smoking cannabis, according to University of California Irvine scientists. That's a high we can get behind. ■

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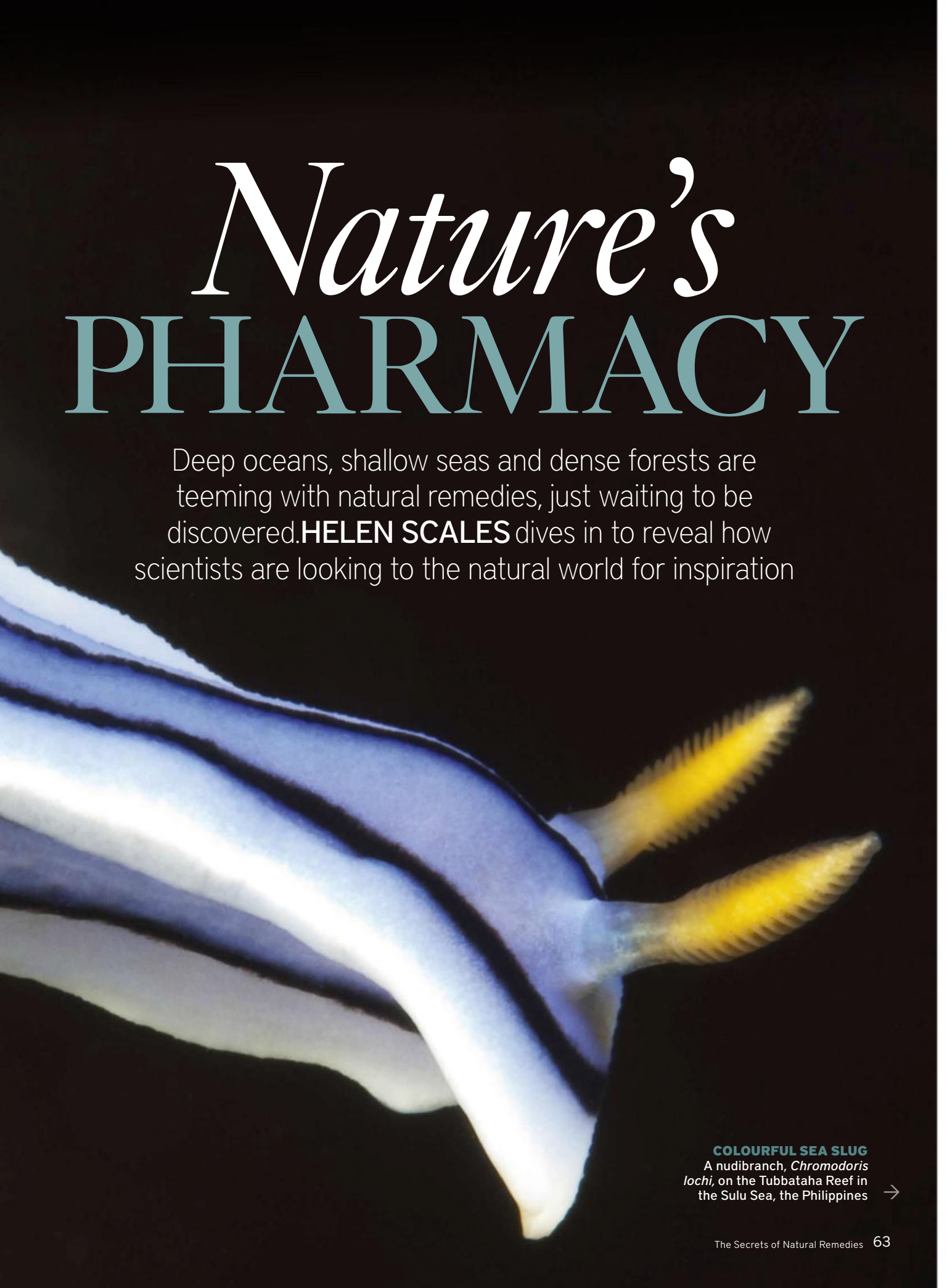
Nature's PHARMACY

Deep oceans, shallow seas and dense forests are teeming with natural remedies, just waiting to be discovered. **HELEN SCALES** dives in to reveal how scientists are looking to the natural world for inspiration



COLOURFUL SEA SLUG
A nudibranch, *Chromodoris lochi,* on the Tubbataha Reef in the Sulu Sea, the Philippines

On a coral atoll in the South China Sea, 300 miles off the coast of Borneo, I prepare for a distinctly unusual scuba dive. Among my equipment are plastic bags, thick rubber gloves and a large chisel – not things I normally need while I'm diving, but essential for what I'm about to do.

I drift downwards through water so clear it feels as if I'm flying. The coral reef stretches out below me like a flourishing garden, every centimetre packed with life. Nearing the bottom I prepare myself to shake off a deeply ingrained instinct: look but don't touch. It's a rule I usually stick to, not only to avoid upsetting the fragile wildlife, but also for my own sake. Plenty of things on a coral reef will bite or more likely sting me. To survive in such crowded neighbourhoods, reef creatures have evolved many means of attack and defence, often involving potent chemical warfare. It's one of the chief reasons why these bustling ecosystems are a focus for so-called 'bio-prospecting'.

For several decades scientists have been searching reefs for novel molecules that could form the basis for new medicines. The first step in the process, and my task on this dive, is to gather samples.

AROMATIC HERB
The sweet wormwood plant, *Artemisia annua*, used to make anti-malarial drugs

Many important Western medicines have their origins in the natural world, such as aspirin from willow tree bark

Inspired by Nature

From fungi that grow in the fur of three-toed sloths to a sea snail's sleep-inducing sting, mud from deep ocean trenches to a Gila monster's drool, there's no saying where the drugs of the future might come from – all are distinct possibilities.

"Nature is the greatest chemist," says Dr. Paul Race, a biochemist from Bristol University. He's one of many scientists tapping into the treasure trove of complex compounds that have been evolving in the wild for millions of years. Known as natural products, these can be almost anything with the potential to provide antibacterial, antiviral, anti-inflammatory, anti-cancer or any number of other health benefits.

Seeking medicinal inspiration from Nature is an idea grounded in centuries-old traditional remedies made from plants and animals, and it's been an immensely successful approach. Many important Western medicines have their origins in the natural world – aspirin from willow tree bark, the chemotherapy drug Taxol from Pacific yew tree bark, and cholesterol-lowering statins from strains of soil-borne fungi.

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CANCER WARRIOR
The sea squirt *Ecteinascidia turbinata* is a source of the anti-cancer drug Ecteinascidin, as found in Yondelis

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In 2015, three scientists were awarded the Nobel Prize in medicine for their natural product discoveries. Chinese chemist Tu Youyou isolated the powerful anti-malarial drug, Artemisinin, from the sweet wormwood plant. Professors William C. Campbell and Satoshi Omura together discovered Avermectin, based on strains of bacteria, which combat river blindness and elephantiasis.

Altogether, in the last 30 years, around half the newly released medicines have been based on natural products, including plenty that were found on coral reefs.

Back in the South China Sea, I zero in on gelatinous animals that fix themselves to the solid structure of the reef and don't move, creatures such as sea squirts and sea sponges. Carefully, I scrape them off, one by one, into plastic bags.

Prialt ziconotide is a non-addictive painkiller, derived from the cone snail, *Conus magus*

Sedentary creatures like these have a proven track record in the search for new medicines. Back in 1969, the US Food and Drug Administration approved cytarabine as an anti-cancer treatment. It was one of the first drugs inspired by marine creatures, this one based on extracts taken from sponges growing on reefs in the Florida Keys. Other reef-based medicines include Prialt, a powerful painkiller developed from the deadly sting of a cone snail, and Yondelis which was discovered in a Caribbean →

NEON SEA SLUG
The nudibranch *Nembrotha kubaryana* in Triton Bay, Papua New Guinea

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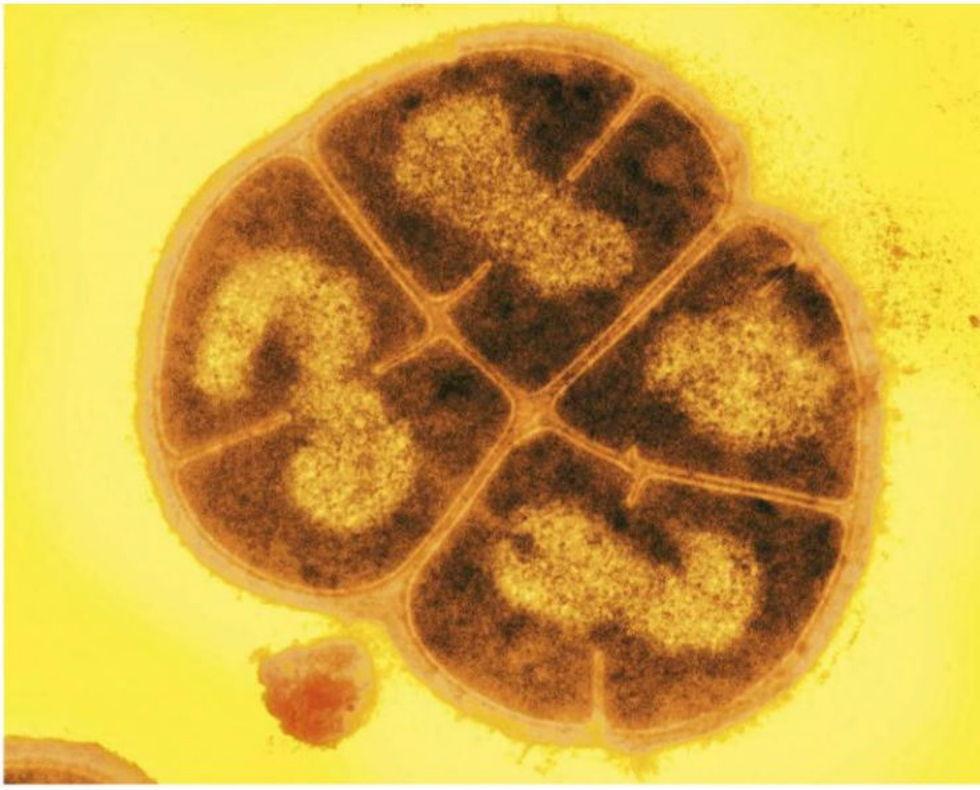
Molecules that are powerful enough to deter hungry predators often turn out to be lethal to cancerous cells too



'CONAN THE BACTERIUM' *Deinococcus radiodurans* got this nickname due to being one of the toughest bacteria on the planet – and hence a potential source for powerful new drugs

sea squirt and FDA-approved as a chemotherapy agent in 2015. Clinical trials are underway for dozens more natural products from coral reef creatures, and not only the ones that stay put.

Brightly coloured sea slugs, also known as nudibranchs, that glide around coral reefs have shown themselves to be a fruitful source of novel molecules. Without a shell for protection, these relatives of sea snails instead load their tissues with bad-tasting, noxious chemicals to ward off attack – their colours are a stark warning of what lies inside. Molecules that are powerful enough to deter hungry predators often turn out to be lethal to cancerous cells too. Sea slugs don't produce these anti-predatory compounds themselves, but acquire and accumulate them from their food, mainly seaweeds and sponges. Researchers are also starting to realise that many new chemicals being found among coral reef dwellers are in fact made by bacteria living inside them.

Bacteria have become a major focus for natural product research for two key reasons. First is the rising tide of drug-resistant 'superbugs' – bacteria that can no longer be treated with standard antibiotics. It's thought that unless new medications are developed, and soon, the annual death toll from untreatable infections could rise to 10 million people worldwide by 2050 – more deaths than from cancer and diabetes put together. On the flip side, bacteria could also provide solutions to this growing problem.

Many research teams are turning to the enormous and largely undiscovered diversity of bacteria, especially those living in extreme environments where life is tough, like in the deep sea, at the freezing poles or in scorching deserts. These 'extremophiles' commonly evolve an arsenal of complex compounds to survive, outcompete and ultimately kill each other.

"It's really these unusual or novel natural products that we're chasing," says Dr. Race.

Deep search

Professor Marcel Jaspars is project leader at PharmaSea, an international research team hunting for new antibiotics in the seas, in particular from deep oceanic trenches.

Getting hold of microbe samples from these remote, harsh places can be challenging. Manned submarines can venture into the depths, but at huge cost. A cheaper option is to deploy so-called 'mud missiles', 1.8m-long probes designed to plunge into the ocean floor and bring back mud samples. And it seems to be well worth the effort.

Prof. Jaspars describes deep sea trenches as 'negative islands' that reach down into the ocean, instead of up. Each isolated chasm is potentially home to its own pool of microbes that have evolved unique chemicals.

"At the moment we have around 13,000 or 14,000 different bacterial strains," says Prof. Jaspars. These were isolated from deep sea mud across the globe, including off Antarctica, China, Chile, New Zealand and South Africa. "We're trying to figure out which are the high value ones," says Prof. Jaspars. "The ones that are actually doing interesting things."

Routine screening involves taking →

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Deadly cone snails under threat

The lethal creatures were once milked for their venom

Collecting mud samples from the deep sea or removing a few sponges from a reef has minimal environmental impact, but bio-prospecting can sometimes lead to problems in the natural world.

For centuries, tropical cone snails have been renowned as some of the deadliest animals in the sea, capable of killing people by impaling them with tiny, toxin-laden teeth. In the 1980s, researchers traced the snails' deadly power to potent molecules in their spit, now known as conotoxins.

Further research revealed that each cone snail species makes hundreds of different conotoxins, each having a highly specific effect on nerve cells, blocking or jamming open signals between them. This makes conotoxins immensely useful tools for medical and neurological research, and as powerful drugs. Consequently, demand for these little animals has soared. Research laboratories around the world became desperate to get their hands on cone snail venom ducts, the fleshy tubes that secrete conotoxins, and for a time the only place to find them was the wild.

Precisely how many cone snails were taken from coral reefs worldwide isn't known, but the number was undoubtedly enormous. Laboratories reported buying venom ducts by the pound, each consignment taken from at least 10,000 snails.

Fortunately for cone snails alternatives were found. First, cone snails were kept alive in laboratories and milked for their venom, originally by persuading them to attack inflated condoms. More recently, molecular advances mean that synthetic conotoxins can now easily be made, and wild cone snail venom is no longer the hot commodity it once was.

Cone snails are venomous, predatory marine gastropods that capture their prey using long, harpoon-like teeth

purified extracts from lab-grown bacteria and testing them against a suite of pathogens. Prof. Jaspars' team are also conducting trials for any likely effects against diseases of the central nervous system, such as epilepsy. "We're finding things that are looking very promising," he says.

A new way to grow bugs

In the chase to find novel microbial molecules, researchers face a major stumbling block – even though the natural world is teeming with microbes, only around one per cent will actually grow in laboratory conditions. And if you can't grow it in the lab, it becomes very difficult to study it. The standard approach is to take samples of soil, deep sea mud or blended sea sponge, separate out the bacteria and culture them on Petri dishes. Roughly one in a hundred bacterial strains will survive in the lab, the rest perish outside their natural environment. Until, that is, a new device came along that is helping to remove this hurdle by convincing bacteria they're still in the wild.

The Isolation Chip, or iChip, is a small, plastic block pitted with hundreds of tiny wells. To set one up all you need to do is take a spoonful of soil or mud, dilute it with water, and pour the mixture into the iChip.

FLPA

Teixobactin is just one of many thousands of bacterial compounds showing huge potential for the future of antibiotics

ISOLATION CHIP This small, plastic block contains hundreds of tiny wells in which bacteria multiply to create hundreds of colonies that scientists can study

Next, cover the wells with a porous membrane that allows nutrients and water to pass through, but not bacteria. Then bury the whole thing in a bucket of the same sediment and leave it for a month or so (and to mimic the deep sea, put it in a pressurised chamber). A single bacterium sits in each tiny well and soon begins to multiply. This gives researchers hundreds of colonies of individual bacterial strains ready for testing, including many that normally refuse to grow in the lab.

The whole thing seems remarkably simple, but it took a research team at Northeastern University in Boston, Massachusetts, more than a decade to perfect. The team's work, led by Professors Slava Epstein and Kim Lewis, hit the news headlines in 2015 when they announced their discovery of a brand new antibiotic.

Teixobactin is made by a strain of bacteria found in a soil sample from a field in Maine. It's just one of many thousands of bacterial compounds newly isolated in iChips, and it's showing huge potential for the future of antibiotics. Anthrax, tuberculosis and the notorious superbug MRSA have all succumbed to teixobactin in lab tests.

Even more promising is the discovery that it could help combat the development of drug-resistance. This new antibiotic works by attacking bacterial cell walls in a way never seen before, and which bacteria may find very difficult to overcome. Within the confines of the lab, the Northeastern researchers did all they could to encourage bacteria to develop resistance to teixobactin, but they failed.

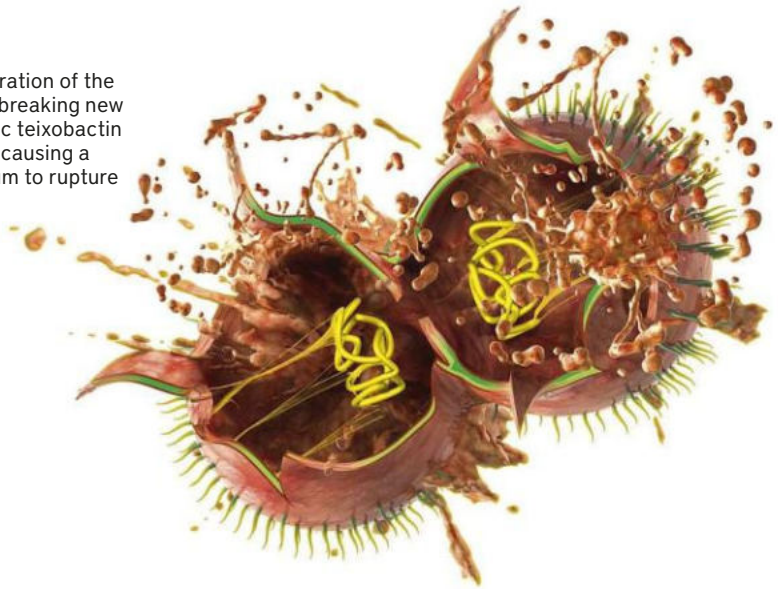
"At this stage there appears to be no route to resistance," says Dr. Race, of the new finding.

Time will tell whether teixobactin makes it to market. In the meantime, Epstein, Lewis and colleagues will continue dipping their iChips into the natural world to see what else they can find.

It's not yet a hundred years since Alexander Fleming made the revolutionary discovery that a patch of mould could kill bacteria. Since then, many more antibiotics have been found, and many of them used and overused until they no longer work against virulent, resistant strains of bacteria. The search for new, more effective medicines has never been more urgent. And even though there are now technologies and powerful research tools that Fleming would never have dreamt of, researchers are still returning to the natural world for inspiration.

Back on the reef, my dive computer tells me that my collecting time is up. I slowly swim to the surface and pass into the boat my plastic sample bags, filled with blobs of shapeless goo. On deck, we empty the bags into plastic trays and meticulously label and document each specimen. Then we parcel them up, ready to freight to laboratories where the task of hunting for useful substances, and maybe even new medicines, will begin. ■

SLAVA EPSTEIN, NORTHEASTERN UNIVERSITY / SCIENCE PICTURE LIBRARY



An illustration of the ground-breaking new antibiotic teixobactin (yellow) causing a bacterium to rupture

Q&A SPECIAL

Expert advice on natural ways to stay healthy, from avoiding jet lag to coping with gluten intolerance, dealing with depression to alleviating allergies...

Why do some people get allergies?

Allergies are caused by an overactive immune system. There's evidence that this is inherited, but many studies have also shown that growing up in an excessively clean environment can trigger allergies. People from big families tend to have been exposed to more bacteria and have a lower chance of developing allergies. But, for example, if you had skin cream containing peanut oil as a baby, you are more likely to be allergic to peanuts as an adult, and soy in formula milk may also trigger peanut allergies, perhaps because the proteins have similar molecular shapes.

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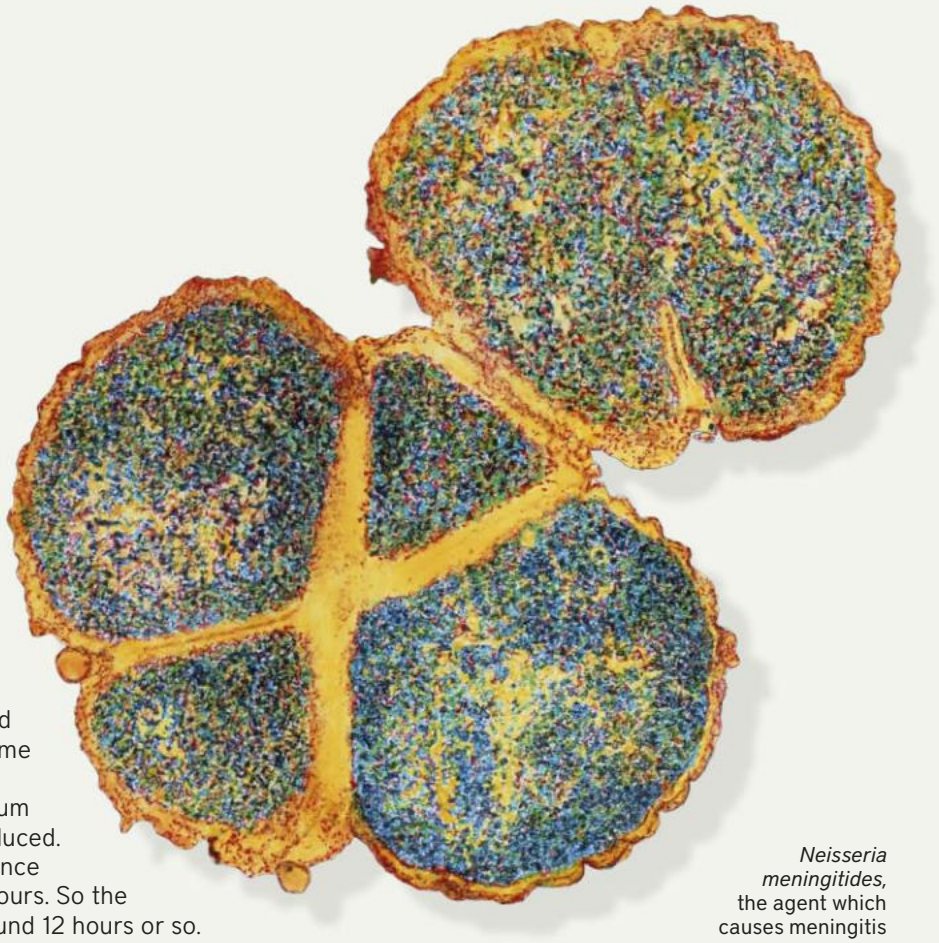
How long does a bacterium live?

Bacteria don't have a fixed lifespan because they don't grow old. When bacteria reproduce, they split into two equal halves, and neither can be regarded as the parent or the child. You could say that so long as a single one of its descendants survives, the original bacterium does too. Individual bacteria can also turn themselves into spores with a tough coat to protect them from dry conditions. Bacterial spores have been successfully revived from 250-million-year-old salt crystals found in New Mexico in 2000. But if we assume that the global bacteria population is stable, then it follows that one bacterium must die for each new one that is produced. Bacteria divide somewhere between once every 12 minutes and once every 24 hours. So the average lifespan of a bacterium is around 12 hours or so.



Neisseria meningitides, the agent which causes meningitis

What should I avoid if I'm gluten intolerant?

Avoid anything with wheat, rye, barley or spelt. That means regular bread, pasta, cereals, cakes and biscuits are out. You will also need to lay off the beer, and read labels carefully, as many processed foods have gluten in them.

But be aware that gluten-free foods are often packed with salt and sugar.

If you think you might be intolerant to gluten, then you should get yourself properly tested to exclude coeliac disease. Around one per cent of the population is affected by this autoimmune condition, where your immune system becomes sensitised to gliaden, a protein in gluten.

When you eat gluten your immune system will not only attack these molecules, but also the lining of your gut, causing inflammation, with common symptoms including bloating, diarrhoea, constipation and weight loss. The only real way to test for coeliac disease is to have a blood test, where doctors look for antibodies. Alternatively, have a biopsy of your small intestine.

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Why do some people get migraines?

Amazingly, the precise cause of migraines is still unknown. These intense headaches, often on one side and accompanied by nausea and sometimes visions of zigzag lines and extreme sensitivity to light and noise, must be caused by abnormal brain activity. But we just don't know what kind or whether there are many different causes.

Hormonal fluctuations, especially in oestrogen, can trigger migraines. So some women suffer more during menstruation, pregnancy or menopause. Certain foods and additives can cause migraines, and people who diet, skip meals or consume a lot of caffeine can suffer. Disturbed sleep and jetlag can also cause them.

One rare inherited type called familial hemiplegic migraine is caused by four specific gene mutations. More common types are also associated with many different genes that affect brain function. The simplest answer lies in the family. Up to 90 per cent of sufferers have a family history of migraines.

Top 10 common foods highest in iron

RDA = recommended daily allowance

1. Liver
Iron in 100g: 23mg
264% men's RDA;
155% women's RDA

2. Dark chocolate
Iron in 100g: 17mg
195% men's RDA;
114% women's RDA

3. Pumpkin seeds
Iron in 100g: 15mg
172% men's RDA;
101% women's RDA

4. Oysters
Iron in 100g: 9.2mg
106% men's RDA;
62% women's RDA

5. Cashew nuts
Iron in 100g: 6.1mg
70% men's RDA;
41% women's RDA

6. Beef
Iron in 100g: 3.8mg
43% men's RDA;
26% women's RDA

7. Lentils
Iron in 100g: 3.7mg
42% men's RDA;
25% women's RDA

8. Spinach
Iron in 100g: 3.6mg
41% men's RDA;
24% women's RDA

9. Tofu
Iron in 100g: 2.7mg
31% men's RDA;
18% women's RDA

10. Quinoa
Iron in 100g: 1.5mg
17% men's RDA;
10% women's RDA

What's worse for your mood – interrupted sleep or shortened sleep?

Interrupted sleep. At least, that's what one recent study shows. We've long known that sleep deprivation makes people bad-tempered and miserable, and that insomnia is linked to depression, but exactly why is less certain. When volunteers slept in a lab and reported their mood every day, some were made to go to bed later than usual, while others had their sleep interrupted several times. Both groups had the same total amount of sleep, but the interrupted sleepers reported worse changes in mood.

The researchers concluded that a lack of slow-wave sleep, which is the deepest type of sleep, was to blame. But these interruptions may be like being woken by a crying baby or a snoring partner. They break into your sleep cycle at random times, therefore disrupting the normal sleep pattern. But if you regularly wake up in the night, you are probably waking at the end of each cycle, and so this would not have the same detrimental effect on your slow-wave sleep.

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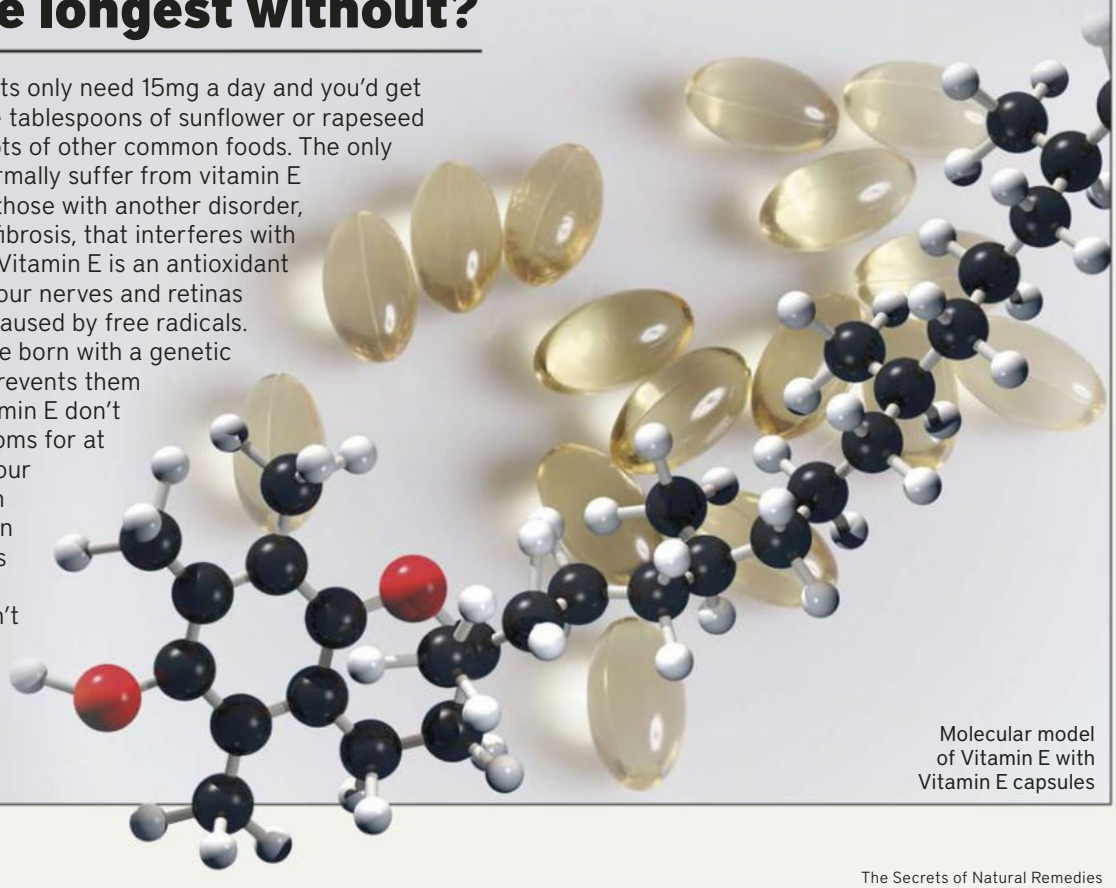
What are the most successful therapies for depression?

There's no simple answer because success depends on age, sex, the type of depression, and whether it's combined with anxiety or other mental-health problems. Generally, therapies based on exploring and changing the patient's own thoughts and behaviour are far more effective than traditional talking therapies, such as psychoanalysis. Alternative therapies, although popular, also fare badly. One meta-analysis combined many studies and found that cognitive behavioural therapy (CBT) did best, especially with long sessions. But a newer therapy called behavioural activation also did well. These are both based on the idea that depression is made worse by adopting the wrong coping strategies. So patients are helped to understand what triggers their depression and how their reactions to life's events affect their moods and emotions. Learning to replace bad coping strategies, such as drugs and drink, with positive coping strategies can help, either used alone or in combination with medication. See page 102 for a good herbal remedy.

What vitamin could you live the longest without?

Vitamin E. Adults only need 15mg a day and you'd get that from three tablespoons of sunflower or rapeseed oil, as well as lots of other common foods. The only people who normally suffer from vitamin E deficiency are those with another disorder, such as cystic fibrosis, that interferes with its absorption. Vitamin E is an antioxidant that protects your nerves and retinas from damage caused by free radicals. But even people born with a genetic disorder that prevents them from using vitamin E don't develop symptoms for at least the first four years. Although the disorder can cause blindness and muscle weakness, it isn't normally fatal.



Molecular model of Vitamin E with Vitamin E capsules

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Six tricks to help avoid jet lag

Travelling long-haul this summer? These simple steps can help you to beat the pain...

Choose the right trip
If you like staying up late, it could be a sign your body clock runs slower than average. People like this find it easier to fly west, but much harder to fly east.

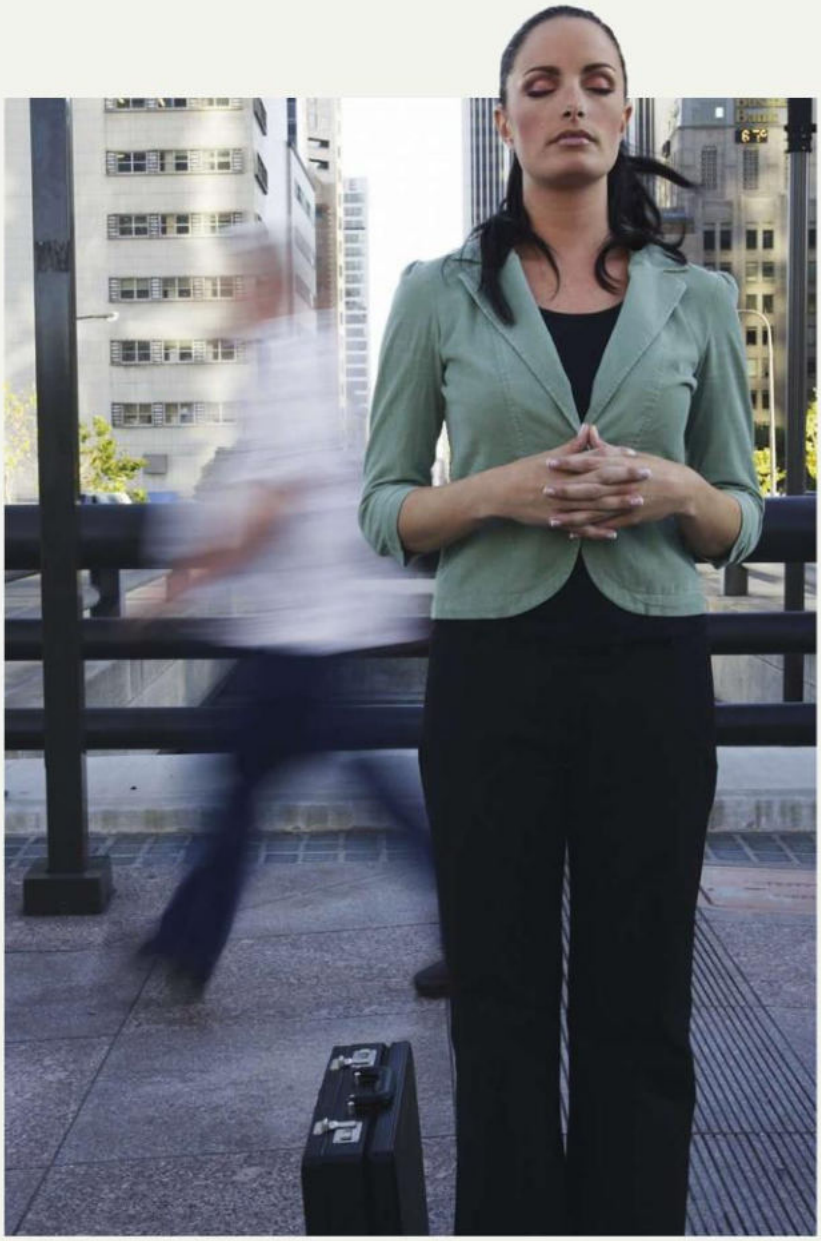
Prepare yourself
If you can, shift your sleep patterns before you fly. If you're flying east, going to bed and getting up a few hours earlier the week before will reduce the difference when you arrive.

Use the flight
Give yourself more time to adapt by changing your watch as soon as you board the plane. You'll have to eat and sleep according to the time at your destination as well.

Keep drinking
Dehydration doesn't help, so drink plenty of water and stay off the coffee. The air on a plane is drier than on land, so you'll probably need to drink more than you usually would.

Catch some rays
Daylight helps you adjust, so go for a walk outside when you arrive. If it's night-time, avoid using laptops and phones – these give off light that confuses your body.

Time capsules
Melatonin tablets are proven to help with trips east if they're taken at the right time, a few hours before bed. In the UK, you'll need a doctor to check it's okay for you.



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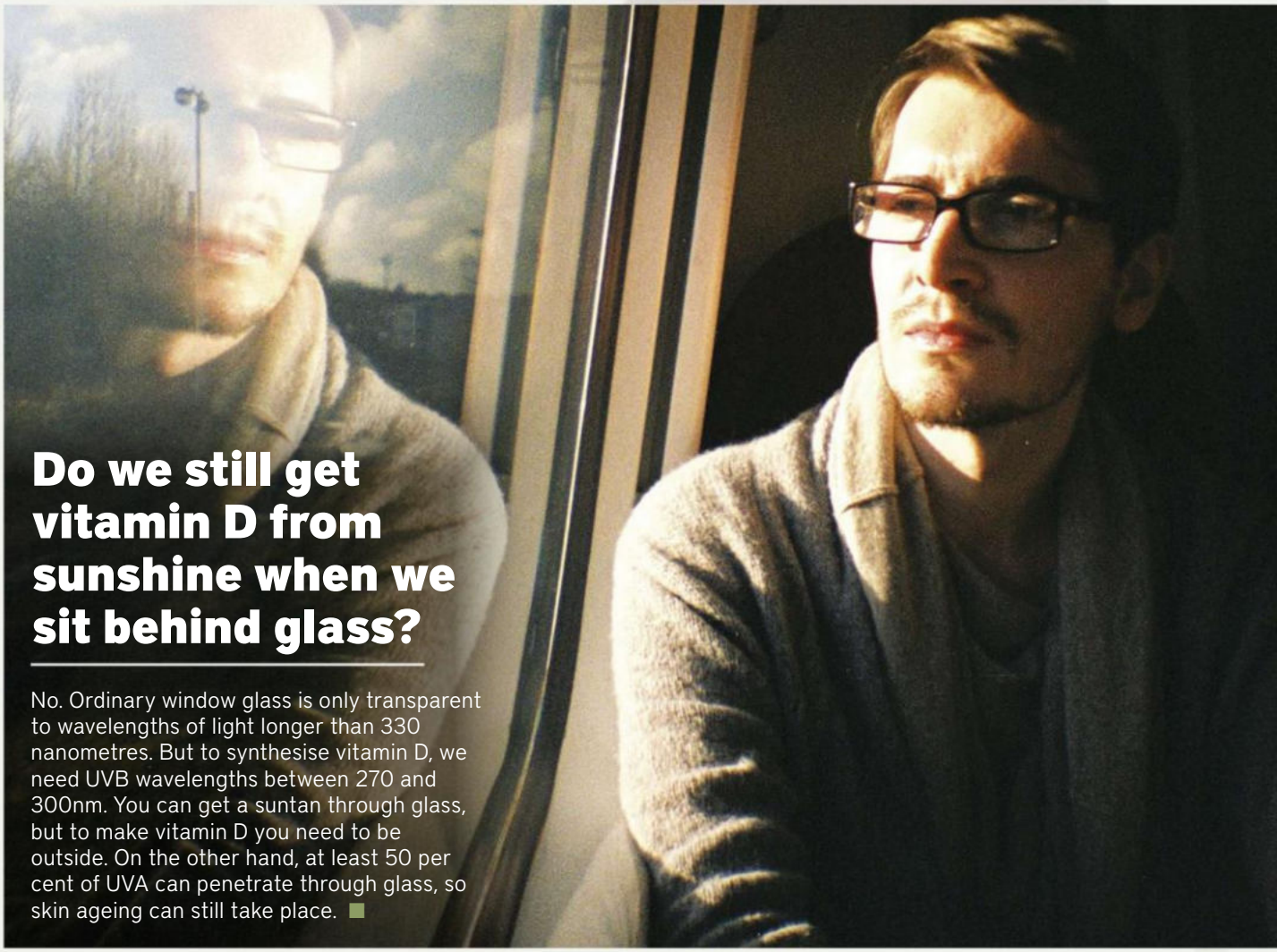
Is mindfulness good for you?

Generally, yes, but not always and not for everyone. Derived from Buddhist teachings, mindfulness means paying steady attention to the present moment without letting your mind wander into fantasies, fears or planning (see page 109). You can practise mindfulness in meditation or in the midst of ordinary life. The Mindfulness-Based Stress Reduction programme claims to decrease anxiety and depression, and increase concentration and wellbeing, with remarkable results reported from prisons, schools, homes and workplaces. Yet many experiments lack proper control groups and few have looked seriously at negative effects. Being mindful is extremely hard at first – trying to clear your mind means facing up to all those unwanted thoughts and fears. This can be painful and disturbing, so some people feel a lot worse before finding the benefits of a calmer mind. Stress hormones can increase even when people say they feel more relaxed, and psychiatrists have warned of troubling side-effects, including a changing sense of self, and floods of traumatic memories. A good mindfulness teacher makes all the difference.

Does locally produced honey prevent hay fever?

No. The myth is that local pollen in honey can desensitise the allergic reaction, but there's no evidence to support it. A 2002 study at the University of Connecticut compared locally-produced, unfiltered honey, with nationally-produced, filtered honey and honey-flavoured corn syrup. In double-blind trials, there was no difference between the three in reducing hay fever symptoms. The pollen in honey is nearly all the heavy, flower pollen that doesn't cause hay fever. The pollen that sets your nose running is much lighter and comes from grasses and trees that bees don't visit.



Do we still get vitamin D from sunshine when we sit behind glass?

No. Ordinary window glass is only transparent to wavelengths of light longer than 330 nanometres. But to synthesise vitamin D, we need UVB wavelengths between 270 and 300nm. You can get a suntan through glass, but to make vitamin D you need to be outside. On the other hand, at least 50 per cent of UVA can penetrate through glass, so skin ageing can still take place. ■

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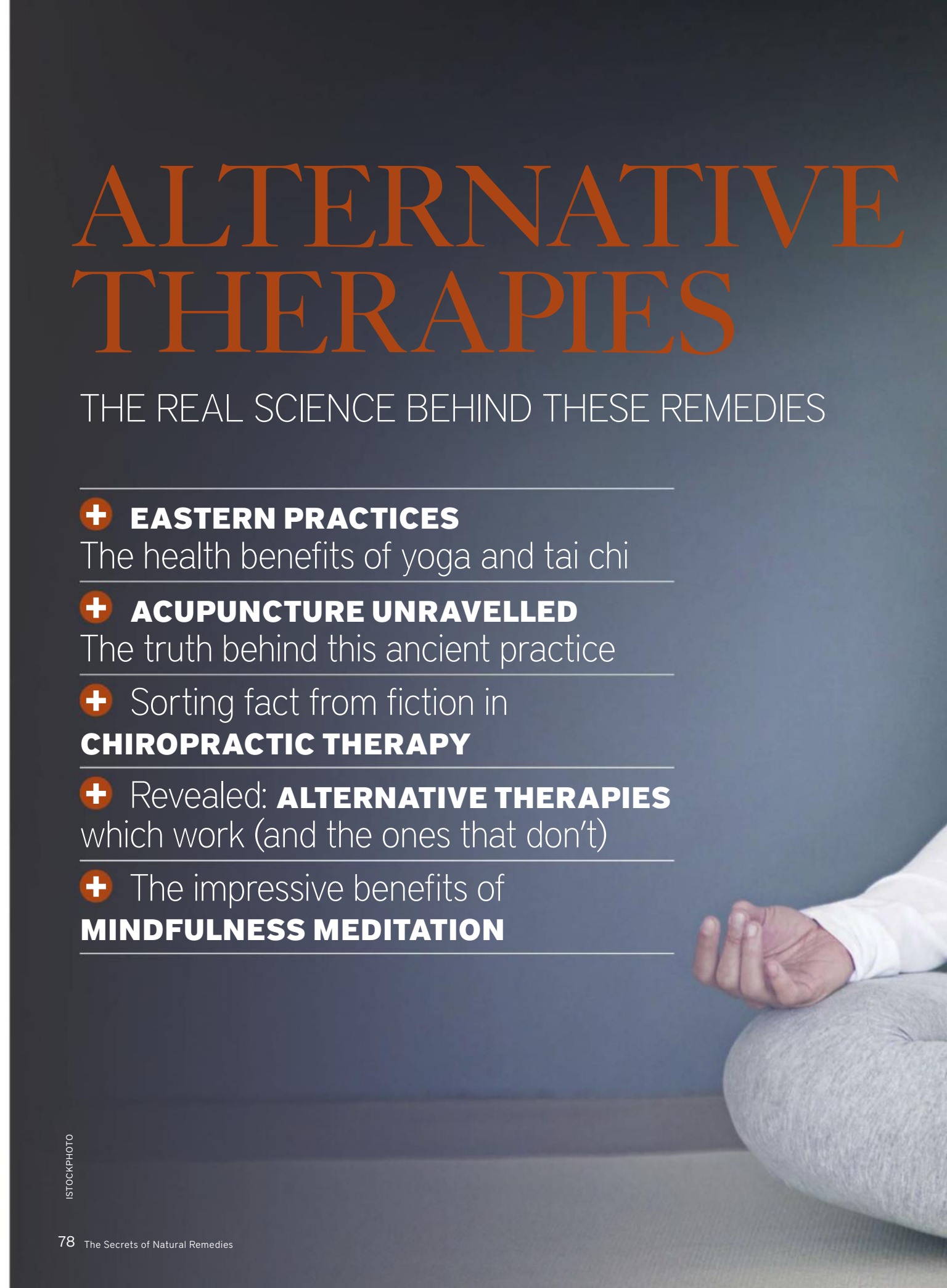
ALTERNATIVE THERAPIES

THE REAL SCIENCE BEHIND THESE REMEDIES

- **EASTERN PRACTICES**
  The health benefits of yoga and tai chi
- **ACUPUNCTURE UNRAVELLED**
  The truth behind this ancient practice
- Sorting fact from fiction in **CHIROPRACTIC THERAPY**
- Revealed: **ALTERNATIVE THERAPIES** which work (and the ones that don't)
- The impressive benefits of **MINDFULNESS MEDITATION**



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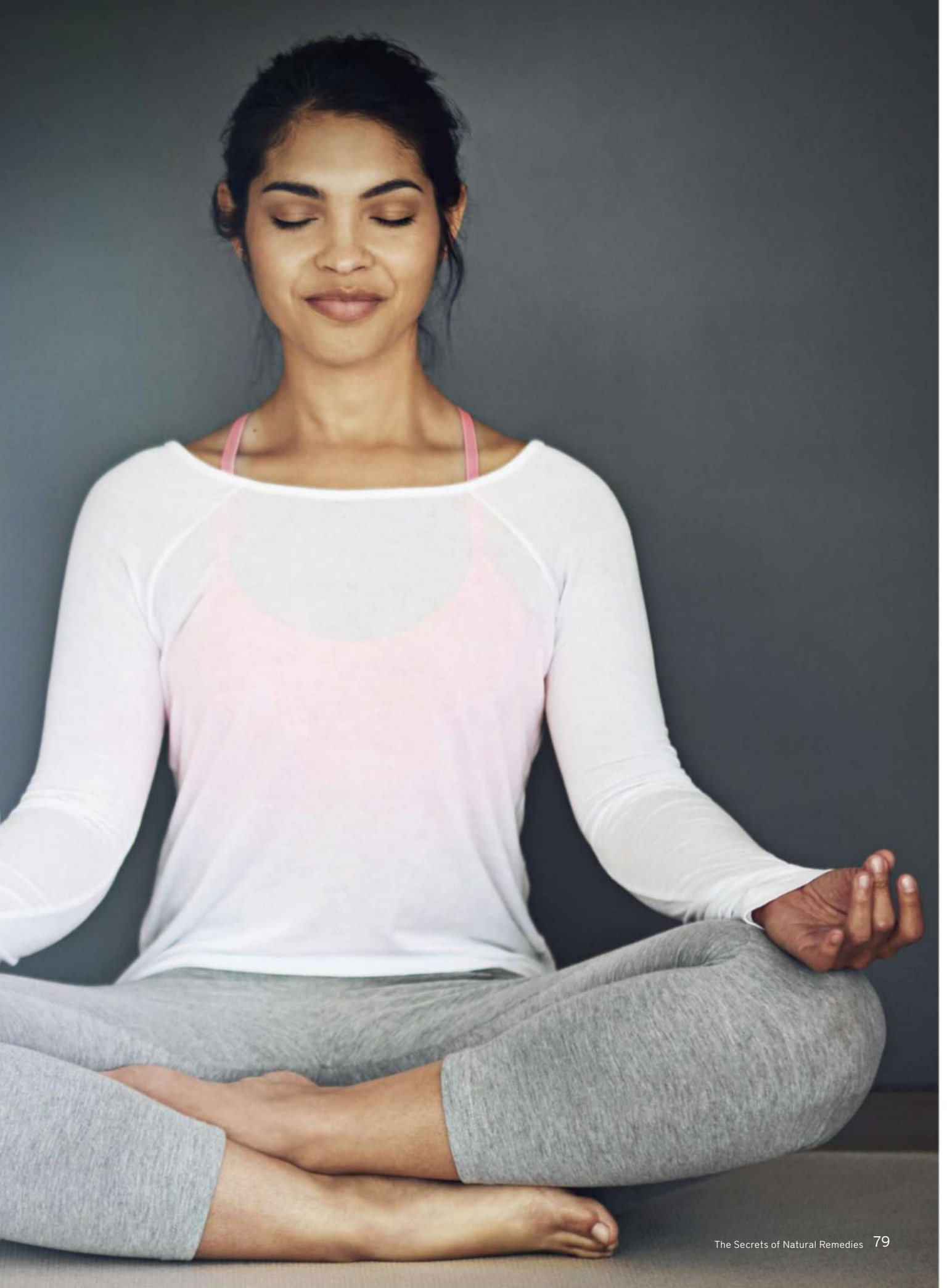

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EASTERN *Influence*

Ancient practices, like yoga and tai chi, have been around for centuries in the East. But following the cultural swing in the '60s, they're now also mainstream in the West. **ZOE CORMIER** investigates their potential health benefits

Chances are you pass at least one yoga studio on your way to work. Where once you laughed at the slightly bizarre-sounding term 'downward dog', it's now likely to be part of your everyday urban dictionary. Indeed, yoga is booming. And devotees claim that daily practise not only helps them stay healthy – it also keeps them sane.

"These are more than mere health-care practices – they're often tied to an entire world view, and once something becomes part of your identity package, it becomes hard to dispassionately address it," says Professor Timothy Caulfield, Research Chair in Health Law and Policy at the University of Alberta, Canada, and author of *The Cure for Everything: Untangling the Twisted Messages about Health, Fitness and Happiness*. "A massive industry has built up around these practices – there's a huge amount of marketing and advertising behind them."

But does that mean there are no benefits? Of course not, he says. But the likes of yoga and other Eastern physical disciplines are on a par with the benefits from any other form of light exercise or focused relaxation.

"There's nothing special or magical about tai chi or yoga. The muscles in your body don't know if you're doing downward dog or bench presses. It's just that there are underlying philosophies to these disciplines that people find emotionally appealing."

Nonetheless, a cursory browse through scientific journals will uncover thousands of studies that purport to show real, measurable biological benefits.

The Red Dragon rises

Take the case of tai chi. This Chinese martial art involves slow but precise movements. Studies claim this gentle exercise has all sorts of benefits: reducing pain, improving memory, treating arthritis, alleviating depression, fine-tuning balance, treating insomnia, and helping with dozens of chronic health conditions from COPD to type 2 diabetes to the side effects of chemotherapy.

One of the biggest problems with all research that purports to show the benefits of complementary medicine, says Professor Michael Irwin, MD, of the University of California, Los Angeles Collaborative Centers for Integrative Medicine, is that they measure the influence of a treatment – say, mindfulness – without comparing it to the influence of a 'gold standard' well-recognised treatment, such as a medication.

"Where is the comparative efficacy

'Yogis' had more grey matter in a part of the brain called the 'insular cortex', which correlated with increased pain tolerance

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GO WITH THE FLOW
A group practices tai chi in Lumpini Park in Bangkok, Thailand

data?" says Prof. Irwin. "As a medical doctor, I need to know if these practices work as well as standard treatments, because we'll never get them into the public health sector unless we can show that they're as efficacious as what's already on offer."

Which is why Dr. Irwin decided to compare cognitive behavioural therapy (CBT) with tai chi, which in the past he had found useful in alleviating insomnia for the elderly. In a study published in the journal *Sleep* in 2014, they reported that when treated with either CBT, tai chi or sleep seminar education, people given CBT fared far better than those with either sleep education or tai chi – it was almost twice as effective.

But Prof. Irwin warns that doesn't mean that we should dismiss tai chi: "There's something more complex going on."

In this – and other studies – tai chi selectively reduced inflammation, as measured by blood levels of a protein called C-reactive protein, which is produced by the liver in response to injury or some other form of physical stress.

"But, while tai chi didn't target sleep behaviour, it did target overarching bodily processes, most importantly inflammation," he says. "When you suffer inflammation you report more depression, fatigue and feelings of social disconnectedness. If you reduce inflammation, you begin to feel better in a number of ways."

So tai chi's many devoted practitioners can feel reassured.

Strike a pose

The Eastern practice that's probably been most widely adopted in the West is yoga. In any given year, seven per cent of American adults practise yoga at some point.

Yoga dates back to the fifth century BCE in India. The practice involves a routine of stretches and poses, combined with breathing exercises and bouts of meditation, and comes in a huge variety of forms – from the athletic (such as Ashtanga) to the more meditative (like Yin) to Westernised versions (such as acroyoga).

Millions anecdotally report a huge range of benefits from increased strength and flexibility, pain relief and heightened energy, to more esoteric psychological effects, such as depression alleviation and reduced anxiety. But what does the science say? Thousands of studies have found numerous benefits. Yoga seems to particularly help alleviate depression caused by insomnia, as it regulates melatonin levels in the blood, aiding sleep patterns. Some studies, however, have made more grandiose claims, such as one in the *California Journal of Health Promotion* from 2015 stating that "yoga in jails helps make better fathers".

Psychologist Dr. Catherine Bushnell, Scientific Director of the Division of Intramural Research at the National Center for Complementary and Integrative Health in the US has investigated the measurable, physical effects of yoga by looking at the brains of people who practise it regularly. In 2014 in the journal *Cerebral Cortex*, she and her co-authors reported that 'yogis' had an increased amount of grey matter in a part of the brain called the 'insular cortex', which correlated with increased pain tolerance. The more experience subjects had with yoga, the more grey matter in the insular cortex, and the more pain tolerance.

Delving deeper into the brain, in 2015 the same team published a detailed report in *Frontiers in Neuroscience* comparing the brains of people who regularly practise yoga with people who do not. Magnetic resonance

Seven per cent of American adults practise yoga in any given year

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WARRIOR II POSE
This yoga posture is also known as Virabhadrasana II

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imaging showed measurable differences in a number of brain regions, which the team say could explain why the grey matter of yogis declines more slowly than their contemporaries. "Yoga seems to offer a protective effect as we age," says Dr. Bushnell. Impressive and detailed as the analysis is, could it just be as Professor Caulfield suggests – the product of exercise, maybe with some relaxation thrown in?

"Prof. Caulfield is absolutely right – there's nothing special about yoga. It's just that the practice combines several different activities that are healthy for you," says Dr. Bushnell. Moreover, yoga may just work particularly well because of the routine and structure that is built into the practice – just as the discipline required for chess or Sudoku may help with someone's mental dexterity.

Mind and matter

One interesting question to come out of Bushnell's neuroimaging work is the relative contributions of the meditative and the physical components of yoga. Both appear to have a significant effect (see page 106), but how do they work in combination? As the effects are difficult to tease out, scientists are not quite sure yet.

What is clear is that yoga can be good for you. So should everybody take it up, as the Prime Minister of India has repeatedly proclaimed? Not necessarily.

If you have limited mobility, due to arthritis or some other health condition, attempting to perform complex positions can be painful,

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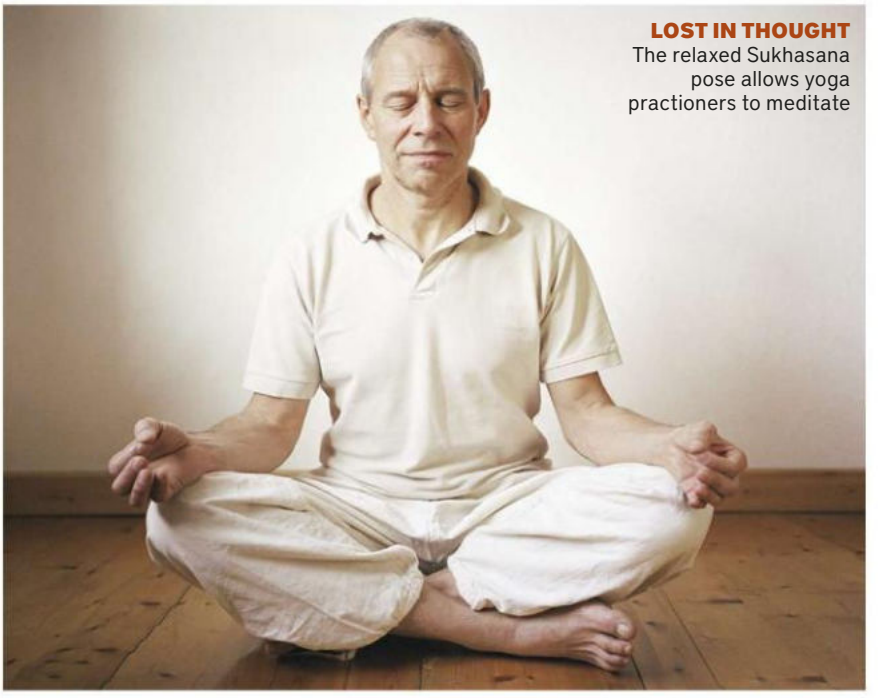
stressful and demoralising. And, for some people, stress can be a catalyst.

Dr. Lisa Uebelacker, Associate Professor of Psychiatry and Human Behavior at Brown University in Rhode Island, US, carried out a small study on people with bipolar disorder, who suffer from dramatic highs and lows, but do not tend to respond to medication for their bipolar disorder. Dr. Uebelacker wanted to find out whether yoga might help, so she conducted an internet survey of 70 yoga practitioners who met all the formal diagnostic criteria for bipolar disorder. Her 2014 report in the *Journal of Psychiatric Practice* showed that the vast majority of respondents felt yoga had a variety of positive effects on their general health, but also cognitive benefits, like feelings of emotional positivity, distraction from worry and increased clarity. The survey contained comments such as: "Yoga reminds me that there can be happy moments," "It deters reclusive behaviour," and "It gives me a break from my thoughts."

Overall, 44 per cent of the respondents said that yoga reduced their manic or hypomanic symptoms, 19 per cent said it sometimes did, and seven per cent said yoga did not reduce their manic symptoms. But here's where things get more complicated: when asked if yoga ever had a *negative* impact on their bipolar symptoms, nine per cent said yes.

> There's nothing special about yoga, the practice just combines several different activities that are healthy for you
>
> *Dr. Bushnell, US National Center for Complementary and Integrative Health*



LOST IN THOUGHT
The relaxed Sukhasana pose allows yoga practioners to meditate

Previous reports, such as in the *Journal of Mental Health, Religion & Culture* in 2001, showed that even sedentary medication can precipitate mania and psychosis.

New, heated forms of yoga, such as Bikram, were even more likely to cause these manic symptoms. Maybe not surprising, as there is physiological evidence that heated yoga can speed the body's metabolism of medications, like aripiprazole.

So, it seems that yoga can be beneficial for many, but potentially dangerous for some. Yet that is true of every form of exercise and mental training. Everybody is different, and there is no such thing as a one-size fits-all solution. Which is exactly what centuries of scientific scrutiny of the human condition has shown – diversity is the norm, and exception is the rule. ■

Acupuncture *Unravelled*

Millions of people around the world use acupuncture for a whole range of conditions. But does science support the practice? Is it really worth turning your body into a pin cushion? **EDZARD ERNST** investigates

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ANCIENT PRACTICE
Acupuncture involves piercing the surface of the skin with fine needles

Of all the alternative therapies, acupuncture is perhaps the best known. Almost everyone seems to have heard that it is ancient, comes from China and involves sticking needles into special points along lines called 'meridians'. But does it work? The answer to this question depends on who you ask.

Sure it works, say the sceptics – it's a powerful placebo (see right), but it has no effects beyond that. By contrast, some physicians claim that it is helpful for a limited range of conditions, yet admit that the effect is far from impressive. And an acupuncturist might explain that his therapy would not have survived thousands of years, if it were not effective – it re-balances the body's life-energy and therefore works for any condition that afflicts humans.

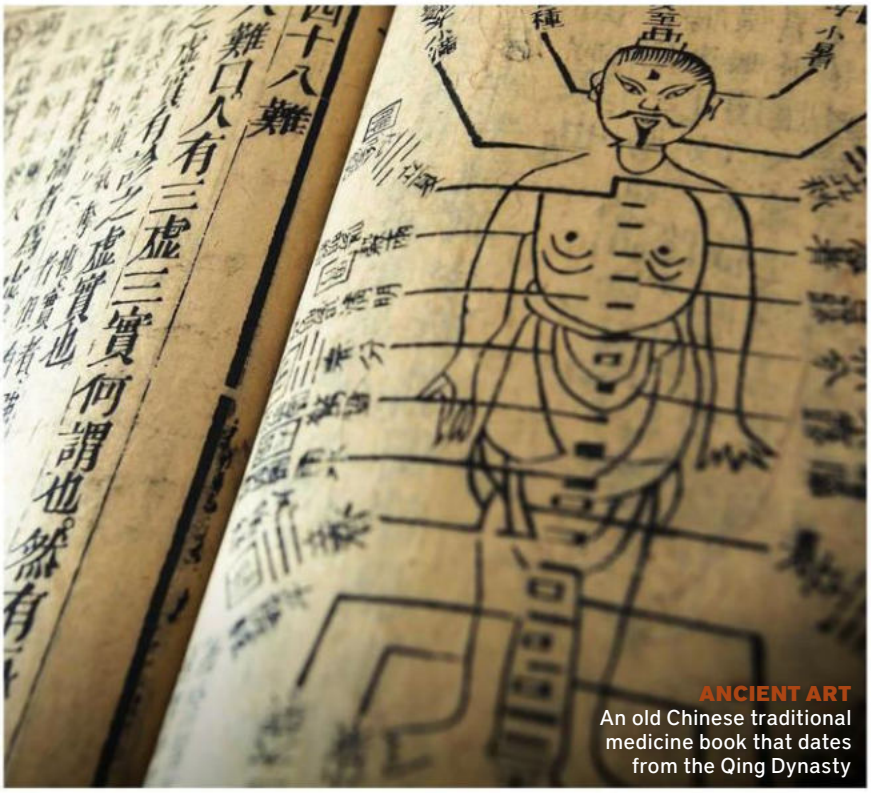
Yes, the realm of acupuncture is rife with opinions and fallacies – and short on certainties. The popular argument that any treatment which has 'stood the test of time' must also be good, for instance, is a classic fallacy that regularly misleads many of us. If we want to know the truth, we better look for some real evidence – and, in medicine, that means results of clinical trials.

Thousands of such studies are currently available. At first sight, this seems like good news, but oddly it is yet another source of confusion – the vast majority of these trials are of such poor quality that they tell us next to nothing. Moreover, several investigations have demonstrated that virtually all studies originating from China arrive at positive conclusions – their reliability is thus less than encouraging. Even if we only assess the seemingly rigorous studies, the picture does not become much clearer: for every trial suggesting that acupuncture works for this or that condition, there is at least one further study showing the exact opposite.

In search of evidence

In such a situation it is tempting to select those results that seem to confirm our preconceived ideas and discretely forget about the rest. However, cherry-picking is a hallmark of pseudoscience of which acupuncture, like all alternative medicine, has more than its fair share. If we are interested in the truth, we must always critically evaluate the totality of the available evidence, and this is best done by conducting what is called a 'systematic review'.

Most experts agree that, among systematic reviews, so-called Cochrane Reviews are second to none – they are regularly updated to the highest standards by independent experts in a transparent fashion. Today, numerous Cochrane Reviews are available, summarising the evidence for acupuncture as a treatment of specific conditions (see 'What the science says' on page 90). What's evident from these publications is fairly obvious – acupuncture has been studied for a



ANCIENT ART An old Chinese traditional medicine book that dates from the Qing Dynasty

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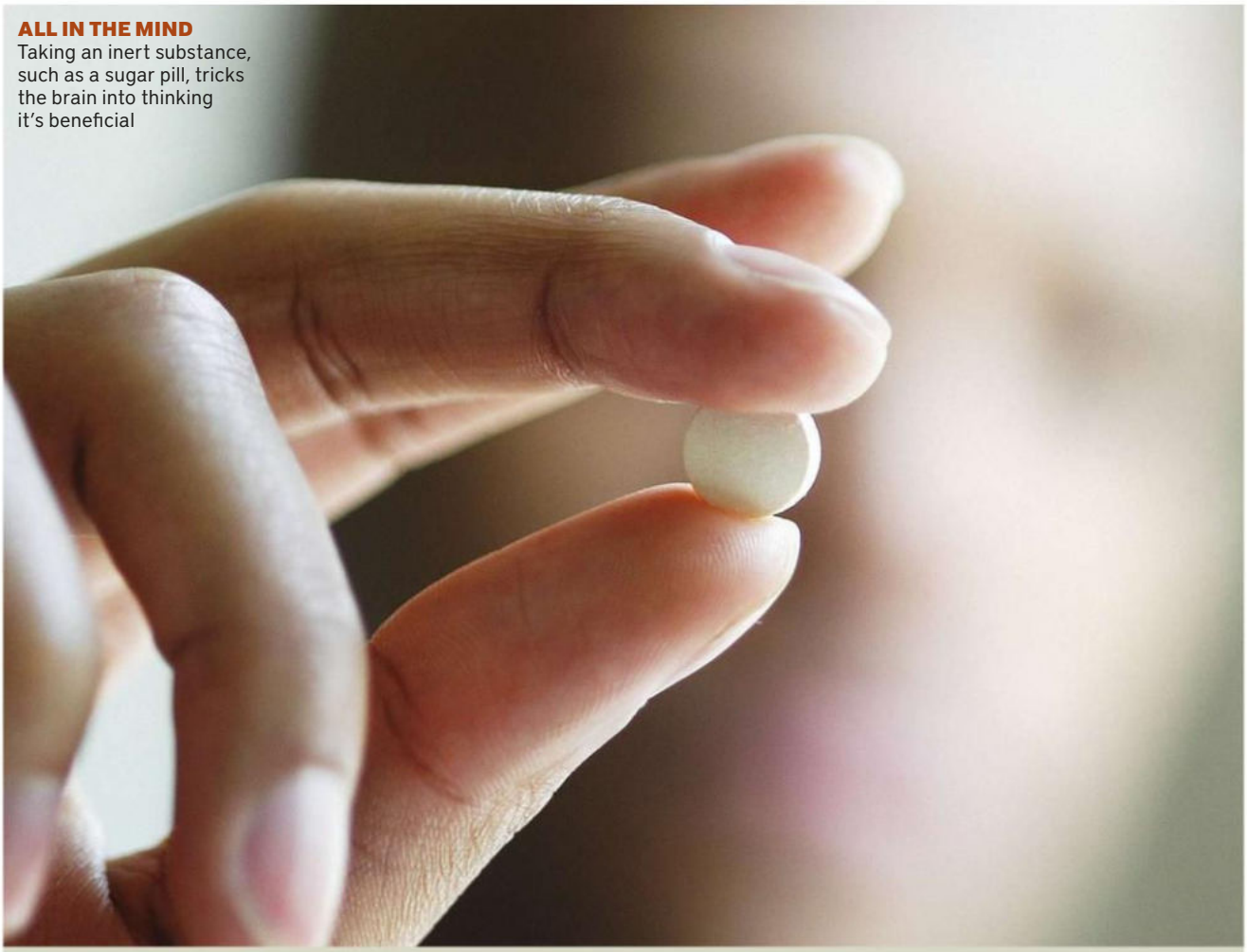
If we want to know the truth, we better look for some real evidence – and, in medicine, that means results of clinical trials



ALL IN THE MIND
Taking an inert substance, such as a sugar pill, tricks the brain into thinking it's beneficial

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The Placebo Effect

How the body reacts when unknowingly given an inert treatment

The mind is a powerful tool. It plays a crucial role in the placebo effect – the beneficial physical effect experienced by a person when they undergo an inert treatment. For example, if someone takes a pill that they think will help alleviate pain, but it's just an inert sugar pill containing no active substance, yet they start to feel better, the placebo effect has been at work.

Every time a person is treated, they experience two main effects: the specific effect of the treatment, and a range of non-specific effects. The latter are largely unrelated to the actual treatment – like the fact that most conditions get better even without treatment, the effects of a compassionate consultation with a healthcare professional, and the fact that humans change when being observed (the Hawthorne Effect). Placebo effects are non-specific effects, and are the result of unconscious conditioning and conscious expectation. Neuro-imaging, and other studies, have found that people experience the placebo response due to a release of certain neurotransmitters.

Non-specific effects can distort the results of clinical trials, and therefore investigators try to minimise them in research. In clinical practice, placebo effects can positively impact the outcome, and thus benefit patients. So, clinicians often try to maximise them. As all therapeutic interventions are associated with placebo effects, they don't necessarily need to administer placebos for that to happen.

If a patient's symptoms are improved after the administration of a therapy, one tends to assume that this is the result of the treatment. However, because the therapeutic response is normally not just the result of the therapy, but also due to a multitude of phenomena, this is not necessarily true. Patients improve even with ineffective or mildly harmful treatments.

What the science says

Conclusions from the 10 most recent Cochrane Reviews on acupuncture

"Acupuncture could be a valuable non-pharmacological tool..." [tension-type headache].

"Acupuncture without electrical stimulation probably does not reduce pain or improve fatigue, overall well-being or sleep" [fibromyalgia].

"The current evidence is not sufficiently rigorous..." [insomnia].

"Acupuncture may reduce period pain."

"We found insufficient evidence to recommend the use of acupuncture for people with depression."

"We found insufficient evidence to determine whether acupuncture is effective for controlling menopausal vasomotor symptoms."

"The current evidence does not support acupuncture for treating epilepsy."

"Sham-controlled RCTs have found no benefits of acupuncture relative to a credible sham acupuncture control for IBS symptom severity or IBS-related quality of life."

"We could not reach any conclusion about the efficacy and safety of acupuncture as we identified no trials for inclusion in this review" [mumps in children].

[The evidence] "does not provide reliable support for either the effectiveness or safety of acupuncture" [sudden onset ankle sprains in adults].

wide range of conditions, and critical assessments of the findings rarely, if ever, generate a convincingly positive verdict.

How could it work?

Given that we cannot be sure whether acupuncture works, it seems almost futile to ask "how does it work?" Yet it is only fair to mention that several theories as to acupuncture's mode of action have been formulated. Traditional acupuncturists tend to adhere to the old Chinese myth that acupuncture works by re-balancing our life-forces when they have become unbalanced. Western acupuncturists, by contrast, are keen on suggestions that acupuncture affects neurophysiological pathways, for instance, by increasing the level of endorphins in the brain. Sceptics would, however, insist that these notions are mere theories. The explanation for both the evidence from clinical trials and the millennia of experience is much simpler – acupuncture has all the qualities of a powerful placebo, as it's exotic, invasive, mildly painful and involves touch and time with a therapist.

But surely the main thing is not the mechanism of action, but the fact that acupuncture helps patients, even if the benefit heavily relies on placebo and other non-specific effects. In this case, do we really need acupuncture? We could simply maximise the placebo effect the best we can, while simultaneously administering treatments that truly work, such as therapies that are effective beyond placebo. According to the best evidence available, acupuncture does not fall into this category.

The slightly paradoxical thing is, we do not need placebo therapies for generating placebo effects – giving effective treatments with compassion and empathy also generates placebo effects, which is an almost inevitable bonus to any intervention. In other words, the placebo effect is no justification for employing these treatments – otherwise we open the door to all sorts of quackery to the detriment of effective healthcare.

The trump card

Time to play the last trump card in the hands of acupuncture fans – safety. At least, our treatment cannot cause any harm, they claim. Yet again, sceptics are not impressed by this argument and stress that this statement is based more on wishful thinking than on sound evidence. Even Chinese acupuncturists recently agreed with this view. They summarised all the adverse events of acupuncture ever published in the Chinese literature, and found 1,038 cases of serious adverse events, including 35 fatalities and hundreds of potentially life-threatening complications. To put this into context, in general, Chinese publications are strongly biased in favour of acupuncture, as shown by an article in *Controlled Clinical Trials*. Thus the level of under-reporting must be assumed to be huge, and the →

Acupunture has all the qualities of a powerful placebo, as it's exotic, invasive, mildly painful and involves touch and time with a therapist

KNEE-DEEP IN NEEDLES
An acupuncturist treats a patient's knee by inserting fine needles into the joint

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LIFE FORCE
Acupuncturists stick needles into special points along lines called 'meridians'

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true figure of adverse effects caused by acupuncture could be much bigger. From large studies done in the West, we know that about 10 per cent of all patients will experience mild to moderate adverse effects after acupuncture. The most frequent type of serious complication is caused by an acupuncture needle piercing an internal organ, such as a lung or the heart. If we add to all this the risks of false diagnoses through the obsolete techniques used by traditional acupuncturists, it's impossible to deny that acupuncture has considerable potential to do serious harm.

A fine line

Considering the complexities, myths, fallacies, uncertainties and confusions around the topic, it is not easy to come up with any clear recommendations for those who are nevertheless tempted to try acupuncture. So if you're planning on giving it a shot, it's worth bearing a few things in mind. It is often claimed that acupuncture has 'stood the test of time', and that its long history proves its effectiveness and safety. This argument is as popular in the realm of alternative medicine as it is misleading. A long history of usage proves very little – think of blood-letting which was used for millennia, even though it killed thousands. Secondly, we often think of acupuncture as being one single treatment, but there are numerous different forms of this therapy and many types of therapists. Traditional Chinese acupuncturists have not normally studied medicine. They base their practice on the Taoist philosophy of the balance between life forces, and could be said to use non-scientific diagnostic methods. In contrast, medical acupuncturists tend to cite neurophysiological explanations as to how acupuncture might work. These may appear scientific and plausible, however, they are just theories and constitute no proof for the validity of acupuncture as a medical intervention. And then there are the therapeutic claims made for acupuncture, which are mostly unfounded.

> According to the more modern view of acupuncture, it might be effective for just a very small range of conditions

According to the traditional view, acupuncture is useful for virtually every condition affecting mankind. But according to the more modern view, it might be effective for just a very small range of conditions. Once we critically examine the reliable evidence, we realise that acupuncture relies heavily on a powerful placebo effect. The question of whether it has effects beyond placebo has so far not been answered conclusively.

Few acupuncturists seem to warn their patients of possible adverse effects. Yet minor side effects occur in about 10 per cent of all patients, and numerous serious complications are on record. Well over 100 fatalities have been reported in the medical literature – a figure which, due to the lack of a monitoring system, may represent the tip of a much bigger iceberg.

Given that there is little good evidence that acupuncture works beyond a placebo response, and that acupuncture is associated with finite risks, it seems to follow that, in most situations, the risk and benefit balance for this treatment fails to be convincingly positive. ■

MERIDIAN LINES
According to acupuncturists, life force, known as 'qi', flows through the body along these intersecting pathways

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TO CRACK *or not to* CRACK

Chiropractic therapy is used to treat all sorts of conditions. But controversy reigns over how effective it actually is. **NATALIE ADAM** investigates

ALAMY

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Many of us get a bad back from time to time. In fact, it's the most common complaint among people who seek medical help. So where do these people go? According to research, a large number of Americans with back pain seek treatment from a chiropractor.

Chiropractors apply pressure to the spine, usually with enough force to produce the characteristic cracking or clicking sounds people associate with the practice. It's thought to come from the (painless) creation and popping of bubbles in the fluid that lubricates our joints. Some patients fear the sound. Others relish it as the audible relief of stiff, tight, or sore muscles.

Chiropractic therapy has been around for over 100 years. Daniel David Palmer came up with the concept in the late 19th century, after he met janitor Harvey Lillard who had suffered from impaired hearing for 17 years. Palmer claimed that he restored Lillard's hearing by moving a misaligned spinal bone, or vertebra, back into its normal position. Shortly after this, he realigned another man's vertebra, reputedly helping to alleviate his heart trouble. Palmer and his co-believers maintained that 'subluxations', which they described as slight misalignments in the vertebrae, were the cause of all health-related problems. This was due to the subluxations causing interference with the flow of what they called innate intelligence (II) – an energy or force within the body. Some chiropractors claim that this undetectable force is responsible for all health complaints.

But there's no scientific evidence to support the existence of such subluxations or innate intelligence. In conventional medicine, the term subluxation is used to describe a partial dislocation of a joint, where the bones meeting at that joint are moved away from their normal position by trauma, such as the impact from a fall. These show up in x-rays, but would not normally be treated by manipulating the joint.

"The chiropractic term subluxation is different and, although some chiropractors claim to be able to see them in x-rays, there seems to be no clear consensus as to what they look like, with different practitioners often seeing greatly varied subluxations in the same spinal x-ray," says former psychiatrist Stephen Barrett, who is now a science writer and co-curator of the website Chirobase, which he runs with retired chiropractor Sam Homola.

Opinions on what to treat differ among chiropractors – and this affects the way they practise. Broadly speaking, the chiropractic community has split into two camps – those that limit their treatments to conditions commonly associated with the musculoskeletal system – the framework of bones and muscles that make up the body – and those that do not. The former are often considered to work more in line with conventional medical beliefs and evidence-based practices. The latter are more likely to be thought of as 'alternative' in their practise. So the big question is – does chiropractic therapy work? The answer, of course, depends on two things: who you ask, and what you ask them.

Many reviews and studies have found inconclusive evidence for the effectiveness of spinal manipulation for low back pain

In search of evidence

In 2010, the General Chiropractic Council – the body that regulates all chiropractors in the UK – funded a review into the effectiveness of

A chiropractor manipulating the lumbar vertebrae

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manual therapies in the UK, and concluded that spinal manipulation and mobilisation has moderate to mild benefits in adults suffering from some types of back and neck pain.

But chiropractors are not the only people to offer spinal manipulation. Primary care physicians, physical therapists and osteopathic doctors do it, too. So why do 40 per cent of North Americans choose to go straight to a chiropractor, compared to 34 per cent who would visit a primary care physician, and just one per cent who would go to a physical therapist or occupational therapist?

Chiropractors increasingly offer a 'one stop shop' says Associate Professor Michael Schneider, from the Department of Physical Therapy, School of Health and Rehabilitation Sciences at the University of Pittsburgh, in the US. "Primary care physicians would diagnose low back pain, and are likely to offer some form of medication to alleviate pain, or referral to another provider for non-pharmacological treatment. A chiropractor provides both the roles of diagnosis and treatment."

Schneider has worked as a chiropractor for over 30 years. In February 2015, he published a study in the journal *Spine* which concluded that hands-on manipulation dealt with low back pain more effectively in the short term than what he deemed "usual medical care" – where physicians advise patients to stay physically active and prescribe over-the-counter medication.

But other reviews and studies have found inconclusive evidence for the effectiveness of spinal manipulation for low back pain, or suggested that there is no clear difference in patient benefit seen from spinal manipulation, compared to other

→

therapies including exercise, no therapy, or the use of non-steroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen.

In 2007, the American Pain Society (APS) and American College of Physicians jointly published clinical practice guidelines on the diagnosis and treatment of low back pain. These recommend "non-pharmacologic therapy with proven benefits", including spinal manipulation, for low back pain. But the guidelines do point out that this is a "weak recommendation", and APS spokesperson Steve Majewski said: "whether a recommendation is weak or strong is based on the quality of the evidence reviewed".

Who carries out a study and how they do it affects this quality of evidence – a view held strongly by Edzard Ernst, Emeritus Professor of Complementary Medicine, the University of Exeter: "Some studies are prone to bias. A good literature review must include some critical assessment of the quality of the methods used. There is evidence that studies authored by chiropractors have more positive conclusions than those authored by independent academics, as there is a conflict of interest."

> Manipulations of the seven uppermost vertebrae can result in an artery supplying the brain to tear, causing a type of stroke

In 2006, Prof. Ernst carried out a systematic review of spinal manipulation, where he analysed collective data from sixteen papers. The verdict – they failed to show that spinal manipulation is an effective treatment for any condition.

The risks

Ineffective is acceptable, but ineffective and risky would cause concern – so what are the side effects? The most common side effect of spinal manipulation is short-term soreness in the muscles around the manipulated area. This is no different to feeling a bit sore after a massage. But there are more serious risks.

"About half of all chiropractic patients suffer from mild to moderate side effects but, as they usually last only two to three days, we might accept them as a necessary step on the way to getting better," says Prof. Ernst. "But much more worrying are the reports of serious complication associated with neck manipulations."

While there are reports of dislocations and fractures, more concerning are the cases of stroke. Manipulations of the seven uppermost vertebrae can result in an artery supplying the brain to tear, causing a type of stroke called a vertebral artery dissection (VAD), as shown in studies such as one by University of California neurologists. This can lead to permanent disability, or even death. "Several hundred such instances have been reported," says Prof. Ernst. "But as there is no effective monitoring system, their true number could be much higher."

But Schneider points out that VAD stroke is rare, and says patients need to consider the risk against benefit when deciding upon a treatment option for neck pain. "Risk is a relative thing. While a stroke is a very significant risk, it is a very low incidence risk that needs to be weighed against the benefits of the manipulation. For low back pain, the benefits seem to outweigh the risks, but if a patient is being treated for a misdiagnosed condition, or one that has no proven benefit, then the risk appears more significant."

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Healing by placebo effect

The debate about the merits of chiropractic therapy gets murkier still when we move beyond the spine. Some chiropractors claim to treat conditions such as asthma and infant

Proprioceptive Neuromuscular Facilitation (PNF) stretching is used to treat torticollis, when the neck becomes 'locked'

SCIENCE PHOTO LIBRARY

colic, which aren't problems normally associated by conventional medicine with the musculoskeletal system.

"If the risks outweigh the benefits, the treatment cannot normally be recommended for routine care," says Prof. Ernst. "In the case of chiropractic therapy, the evidence suggesting that it is effective is limited to very few conditions, and even there it is too weak to claim it is of proven effectiveness. It follows that the risk/benefit balance of chiropractic manipulations is rarely encouraging."

But, despite the mainstream scepticism, huge numbers of Americans still visit chiropractors every year. So what's the benefit? It could simply be an increasing desire to avoid pills and a placebo effect (see page 89), linked to the one-on-one attention of a caring practitioner.

"Pain is linked to fear," says Jo Marchant, a science writer and author of *Cure: A Journey into the Science of Mind over Body*. "Stress and fear create biological changes in the brain that amplify our symptoms. Trials suggest receiving empathetic care, as well as having positive expectations for treatment helps to reverse this. Psychological influences such as empathy, social interaction and expectation create biological changes that ease pain. So it's not an illusion, or a change in perception, the pain is reduced through just the same physical mechanism as when you take a painkiller." ■

ALAMY

Alternative THERAPIES
The Good, the Bad and the Ugly

From homeopathy to hypnotherapy, **EDZARD ERNST** looks at some well-known alternative therapies and medicines – revealing which can work and which to avoid

Alternative therapies is the umbrella term for a diverse array of treatments, which have little in common, other than not being accepted by most conventional healthcare professionals. So any general judgements about their effectiveness are somewhat nonsensical. Very few alternative therapies are supported by sound evidence and, to the best of our knowledge, none works better than the conventional treatment available for a specific condition.

Why then are they so popular? One reason is that – rightly or wrongly – conventional clinicians are often unable to build therapeutic relationships with their patients that are as empathetic and compassionate as those of alternative practitioners. In other words, the current popularity of alternative medicine is also a poignant criticism of modern health care.

Most of us think that alternative treatments are natural, and hence risk-free. This is dangerously wrong, because nature is not necessarily harmless, and seemingly innocent treatments, such as homeopathy, can become potentially life threatening. For example, if a cancer patient forfeits conventional treatments in favour of some homeopathic remedies, their life is in grave danger.

So, the take-home message is to be cautious, and study the evidence carefully and critically. If an alternative therapy sounds too good to be true, it probably is!

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THE GOOD

Alternative treatments with encouraging evidence that they work

Herbal medicines clearly fall into this category. They usually contain a multitude of pharmacologically active ingredients, so it's hardly surprising that some of them are effective. Perhaps the best researched herbal medicine is St. John's Wort, which is used mostly for mild to moderate depression. The most recent systematic review showed that St. John's Wort extracts were "superior to placebo" in treating depression, as effective as conventional anti-depressants and "associated with significantly fewer dropouts because of adverse effects". (Having said that, St. John's Wort interacts with around half of prescription drugs, so should be taken with care – see page 105.)

If herbal extracts can be that good, why not isolate the active principle from the messy concoction of ingredients and market them as pure compounds? This is precisely what many scientists try to do, sometimes with huge success. Aspirin, for instance, has been derived from the willow bark and has become one of the most successful drugs of all time. But for other herbs, such as St. John's Wort, this approach is not viable, because one single ingredient from the whole range of active compounds in the extract turns out to be far less effective than the full plant extract with its multitude of ingredients.

Hypnotherapy is being promoted for many conditions including pain, anxiety and smoking, but for none is the evidence stronger than for irritable bowel syndrome (IBS). A recent review summarised the findings from 25 clinical trials, and concluded that "collectively this body of research shows unequivocally that for both adults and children with IBS, hypnosis treatment is highly efficacious in reducing bowel symptoms, and can offer lasting and substantial symptom relief for a large proportion of patients who do not respond adequately to usual medical treatment approaches". This might be on the optimistic side, but it is nevertheless clear, that hypnotherapy shows some promise.

Some experts might object because they would not categorise hypnotherapy as an alternative treatment. They might have a point: one of the most notorious problems with alternative therapies in general is that, once a therapy has been shown to work, it will be accepted by health care professionals, and thus ceases to be 'alternative'.

St. John's Wort extracts were "superior to placebo" in treating depression

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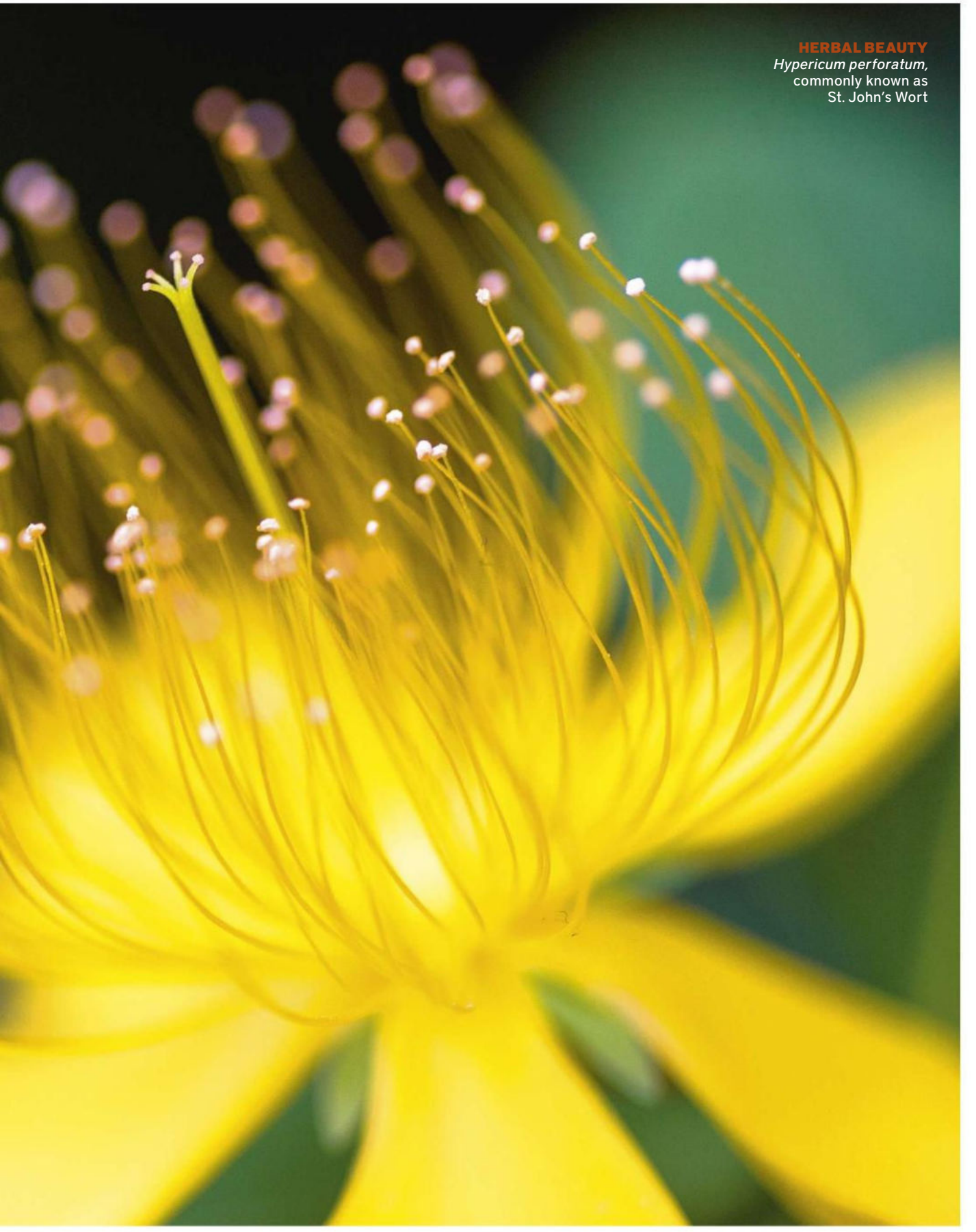

HERBAL BEAUTY
Hypericum perforatum, commonly known as St. John's Wort

THE BAD

Treatments that have been shown to be ineffective

Few treatments fit better into this category than homeopathy. It was invented about 200 years ago by the German doctor Samuel Hahnemann, who thought that 'like cures like'. Essentially, this means that, if your eyes start watering when you cut an onion, a homeopath would use the onion to cure conditions which are associated with runny eyes. But homeopaths don't just administer the onion, they dilute the extract many times until typically not a single molecule of it is left in the remedy they prescribe.

Of course, such features render homeopathy utterly implausible. So, it is hardly surprising that the 300-odd clinical trials, which have tested its effectiveness for various conditions, fail to show that homeopathic remedies are more than pure placebos (see page 89). Science is normally a poor tool for proving a negative, but in the case of homeopathy the evidence is now fairly clear (it is only homeopaths who refuse to accept it). The most thorough assessment of homeopathy has recently been published by the National Health and Medical Research Council of Australia. The conclusions of this austere panel could hardly be more straightforward: "...there are no health conditions for which there is reliable evidence that homeopathy is effective. Homeopathy should not be used to treat health conditions that are chronic, serious or could become serious."

Meanwhile, spiritual healing is the term often used for treatments such as Reiki, Therapeutic Touch, and other para-normal healing methods. Healers claim to channel healing 'energy' into a patient's body, where it allegedly stimulates their self-healing mechanisms. There have been numerous studies of these treatments, and the most rigorous of them seem to agree that the effects are due to placebo.

A recent study was aimed at testing the effectiveness of energy healing on the wellbeing of 247 colorectal cancer patients. Compared with other patients who had not been exposed to the healing 'energy', no overall effect of healing was noted on quality of life, depressive symptoms, mood or sleep quality. The authors concluded that the healing effectiveness on wellbeing was, however, related to factors such as self-selection and a positive attitude toward the treatment.

POINTLESS PILLS
Vials containing pills for homeopathic remedies

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BUY WITH CAUTION
Ingredients for sale at a Traditional Chinese Medicine store

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THE UGLY

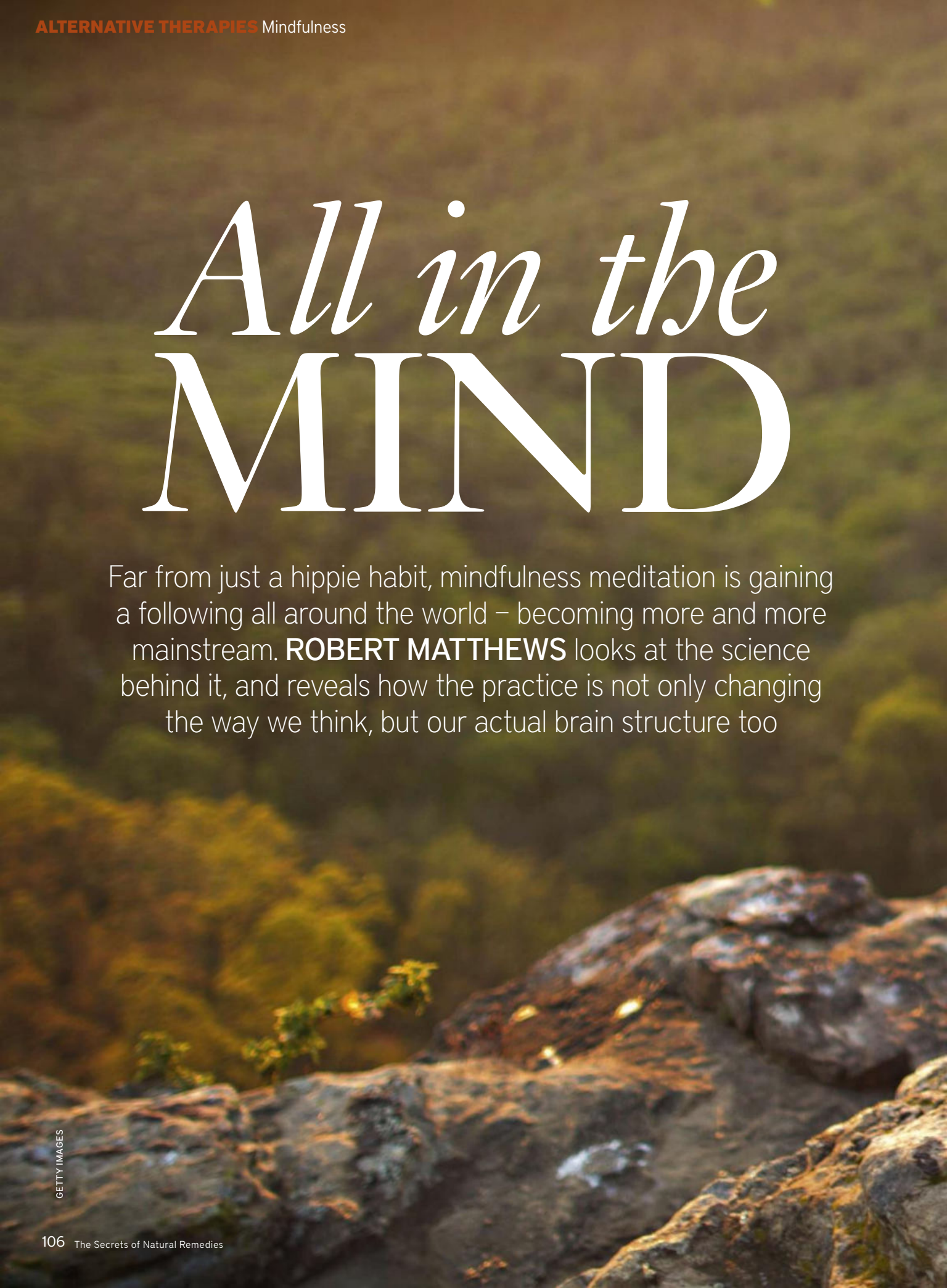
Potentially harmful treatments that should be avoided

Asian herbal remedies are notorious for being adulterated with synthetic drugs, and some investigations have shown that more than a quarter of Chinese herbal creams contained potentially damaging corticosteroids.

While many herbal medicines, such as St. John's Wort (see page 102), contain pharmacologically active ingredients, some herbal medicines can also do harm. There are many plants that have been shown to contain toxic substances – causing damage to the liver, kidneys or other organs. Other herbal medicines have the potential to interact with prescribed medicines. For instance, St John's Wort interacts with about 50 per cent of all prescription drugs, and so the blood level of the prescription drug can become too low to have the desired effect. In turn, this can mean that a prescribed anticoagulant no longer protects a patient from a potentially deadly blood clot, or that a woman gets pregnant despite taking oral contraceptives. And then there is the risk of contamination or adulteration. Recently the UK regulator recalled a large quantity of St. John's Wort tablets because they were contaminated with a liver-toxic compound originating from another plant that inadvertently made its way into the remedy. ■

All in the MIND

Far from just a hippie habit, mindfulness meditation is gaining a following all around the world – becoming more and more mainstream. **ROBERT MATTHEWS** looks at the science behind it, and reveals how the practice is not only changing the way we think, but our actual brain structure too



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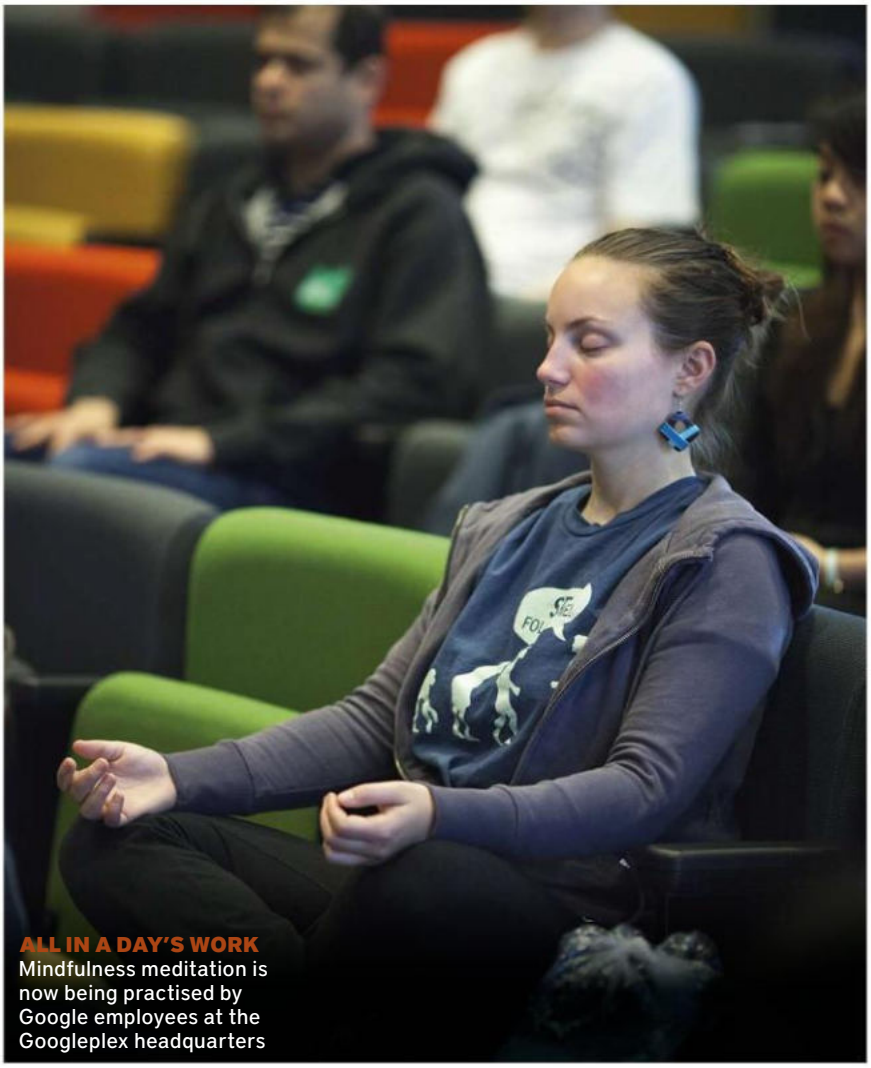
After years of battling chronic pain, Anne* had all but given up hope of finding a safe but effective source of relief. So when a friend asked her to try a radically different way of dealing with her affliction, she agreed.

As it involved sitting and actually focusing on her pain, she could have been excused for having her doubts. Yet after trying it for eight weeks, Anne was so impressed by the results she decided to make it part of her life: "I use it all the time, and it helps me with my pain."

She's far from alone. Millions of people are now using mindfulness meditation to deal with a host of conditions, from stress and depression to physical pain and binge eating.

Based on ancient practices once deemed the preserve of religious ascetics and hippies, the claims now being made for mindfulness meditation are impressive – so much so that multinationals like Google and Ikea have embraced it. Last year an All-party UK Parliamentary Group called for its adoption by schools, hospitals and prisons. Meanwhile, there's been an explosion in the numbers of courses, books and websites offering to bring the power of mindfulness to us all. And of course, there's no shortage of apps for it.



ALL IN A DAY'S WORK
Mindfulness meditation is now being practised by Google employees at the Googleplex headquarters

PETER DASILVA/THE NEW YORK TIMES/REDUX/EYEVINE

Science or self-deception?

Yet can so simple a technique really achieve so much? Or do the claims really say more about the power of self-deception – and what are the risks of taking them seriously?

Until recently, evidence for the effectiveness of the technique was almost entirely anecdotal. While millions of practitioners insisted it worked for them, its association with mysticism and navel-gazing led most scientists to avoid investigating it. Yet without proper scientific evaluation, what could be a genuinely effective technique might never reach those who could benefit from it.

The scientist generally credited with breaking the deadlock is Jon Kabat-Zinn. As a molecular biology PhD student at the Massachusetts Institute of Technology in the US, he began practising Zen Buddhist meditation in the 1970s. His experiences led him to try distilling its essence into a non-religious form he thought might benefit others.

Known as Mindfulness-Based Stress Reduction (MBSR), it was based around the practise of simply observing one's own mind at work, and noting what thoughts arise from moment to moment without →

> The claims now being made for mindfulness meditation are impressive, so much so that multinationals like Google have embraced it

In a nutshell

What mindfulness meditation is – and what it isn't

The very idea of meditation comes with a lot of baggage and misconceptions. Some believe it demands religious faith. Others think it requires hours of sitting in the lotus position while banishing all thought.

In reality, mindfulness meditation simply involves becoming aware of one's thoughts, feelings and surroundings without judgement.

It can be done anywhere, anytime, though beginners are advised to start practising in a place where they can sit quietly for a few minutes without distraction.

The idea is then to become aware – 'mindful' – of some aspect of the present, such as one's own breathing, and focus one's thoughts on that.

This may sound simple, but even experienced practitioners often find that within seconds their minds have wandered. The intrusive thoughts can be anything from memories of past arguments to feelings of cosmic bliss. But, the key to mindfulness is simply to note that the thought has arisen and return to focusing on the breath.

The classic beginner's mistake is to feel bad about having intrusive thoughts or become lost in them. "The brain will always produce thoughts – that's what it does," says Harvard psychologist and mindfulness expert Dr. Chris Germer, author of *The Mindful Path to Self-Compassion*. "Mindfulness allows us to develop a more harmonious relationship with our thoughts and feelings."

Starting with short sessions of five minutes, the duration of the sessions can be built up to 30 minutes or more. However it's done, practitioners typically become increasingly aware of the vagaries of the mind, and how acceptance of even 'bad' thoughts helps rob them of their power.

But as interest in mindfulness meditation has grown, so have reports of people having negative reactions to it. Some find themselves experiencing traumatic thoughts, panic or even loss of the sense of self.

According to Dr. Germer, such responses can be a sign of being too hard on oneself: "Most adverse effects are caused by too much formal sitting meditation practise." He advises being less demanding – adding that one is still practising mindfulness when just noticing, say, the warmth of the water during a morning shower.

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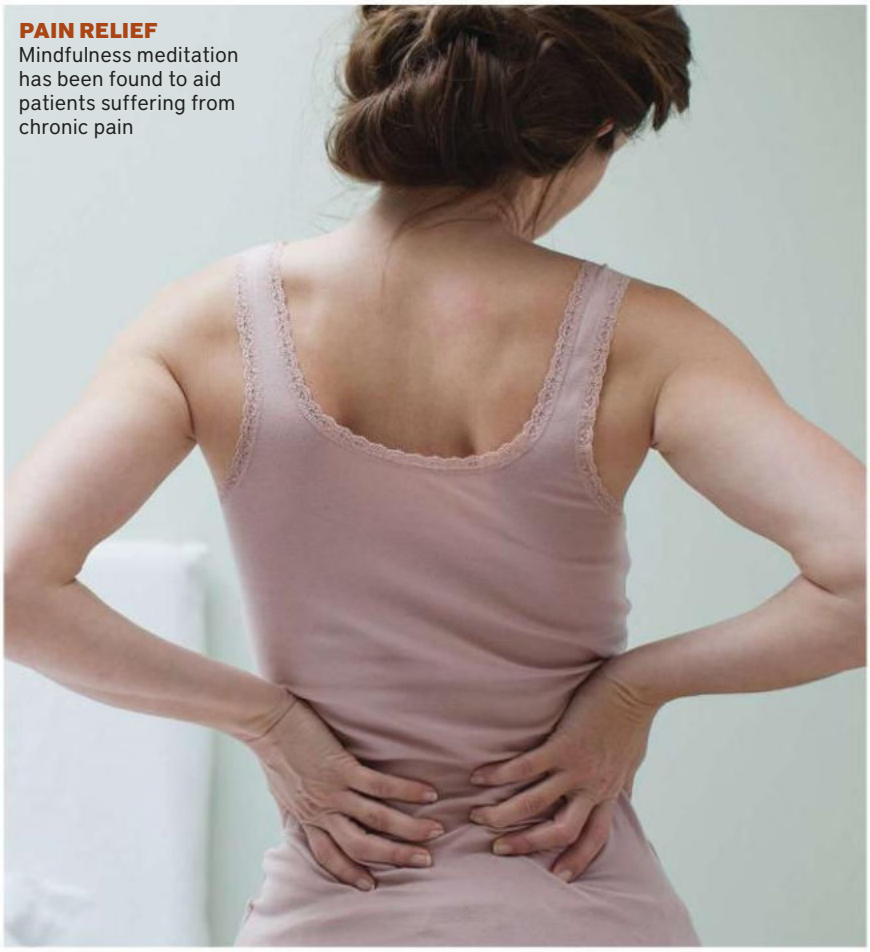

PAIN RELIEF
Mindfulness meditation has been found to aid patients suffering from chronic pain

judgement (see page 109). Thus, regardless of whether the thoughts seemed good or bad, the practitioner simply noted their existence, and let them go.

By the 1980s, Kabat-Zinn had begun reporting the outcome of his studies of MBSR in serious scientific journals. These suggested that the technique could be effective for more than just stress and anxiety. Patients suffering from chronic pain that had defied conventional treatment reported feeling significantly better after a 10-week course in mindfulness methods.

In what has since become a familiar feature of studies on mindfulness, patients did not report having rid themselves of all pain. Instead, they talked of having changed their response to it. Using the mindfulness methods, they had learned simply to note the existence of the pain rather than judge it as bad – and, in the process, found they had robbed it of much of its power.

Real-world benefits

Other researchers began reporting similar benefits in an ever-growing list of ailments and conditions, from depression in pregnant women to post-traumatic stress disorder in war veterans. Mindfulness also seemed to help with behavioural problems, ranging from hostility among prisoners to attention deficits of schoolchildren.

Mindfulness even appeared capable of reducing binge eating among people struggling with their weight. Impressed by Kabat-Zinn's findings, Jean Kristeller of Indiana State University in the US developed Mindfulness-Based Eating Awareness Training (MB-EAT), which involves focusing on the sensation of eating – starting with the mindful consumption of raisins. Kristeller and her colleagues found that over time, the technique allowed their patients to better control their bingeing, and also became less depressed.

Yet while the breadth of applications of mindfulness expanded, the depth of the evidence remained limited. Many of the claims were based on observations of small groups of patients. Few were based on so-called 'randomised controlled trials' (RCTs), in which patients are randomly allocated either to receive mindfulness training, or a more conventional treatment, or none at all.

Regarded as the gold standard for assessing the value of conventional therapies, RCTs are time-consuming and expensive to carry out. Yet without them, claims for the effectiveness of mindfulness techniques risked remaining forever less than compelling. →

A new diet: people struggling to control their binge-eating are finding mindfulness helps

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Without randomised controlled trials, claims for the effectiveness of mindfulness risked remaining forever less than compelling

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Researchers are uncovering startling evidence that the practice actually changes the physical structure of the brain

Now the results of RCTs are starting to emerge, with intriguing results. In 2011, a team led by Lone Fjorback at Aarhus University Hospital in Denmark, published a systematic review of 11 RCTs of mindfulness-based treatments for mental health issues. According to the team, the treatments did appear to significantly improve mental health and reduce the risk of falling back into depression.

In 2013, the journal *Clinical Psychology Review* published the result of an analysis of over 200 separate studies, in an attempt to give a broad view of effectiveness. According to lead author Dr. Bassam Khoury of the University of Montreal in Canada, the results were again encouraging: "Mindfulness-based therapies were found to be highly effective in treating psychological disorders – namely anxiety and depression – and somewhat effective in diminishing psychological symptoms associated with physical or medical conditions, like pain."

The conclusions of Dr. Khoury's team have now been echoed by the latest state-of-the-art review published last year in *Nature Neuroscience*. According to its authors, "Research over the past two decades broadly supports the claim that mindfulness meditation […] exerts beneficial effects on physical and mental health, and cognitive performance."

But the team also noted that all this still left one huge question unanswered: how does mindfulness actually work?

Re-wiring the brain

Regular practitioners often talk of acquiring better insight and control of the seemingly random flow of thoughts, feelings and emotions through the mind. That, in turn, seems to reduce their significance and impact.

It's becoming clear, however, that mindfulness meditation works at more than just the level of conscious thought. Researchers are uncovering startling evidence that the practice actually changes the physical structure of the brain.

This astonishing phenomenon first began to attract attention around a decade ago, following studies of Buddhist monks carried out by neuroscientist Richard Davidson at the University of Wisconsin, US.

The monks appeared to have patterns of brain activity significantly different to that of untrained students used as 'controls'. And while all of them had practised meditation in Tibetan monasteries for many years, the differences were most marked with the most experienced meditators.

This intriguing finding led other researchers to use more sophisticated methods capable of detecting actual physical changes in the brain. And the findings suggest that specific parts of the brain are indeed modified by meditation.

According to the most comprehensive review of the research so far, published in *Neuroscience and Biobehavioral Reviews* in 2014, one of the most consistent findings is modification of a region at the front of the brain called the rostrolateral prefrontal cortex (RLPFC).

"While this region plays many roles, it is particularly crucial for meta-cognition and introspection," explains Kieran Fox of the University of British Columbia in the US, lead author of the study.

Another consistent finding was changes in the dorsal anterior →

SEEING THE LIGHT
Mindfulness-based therapies have been found to be effective for treating anxiety and depression

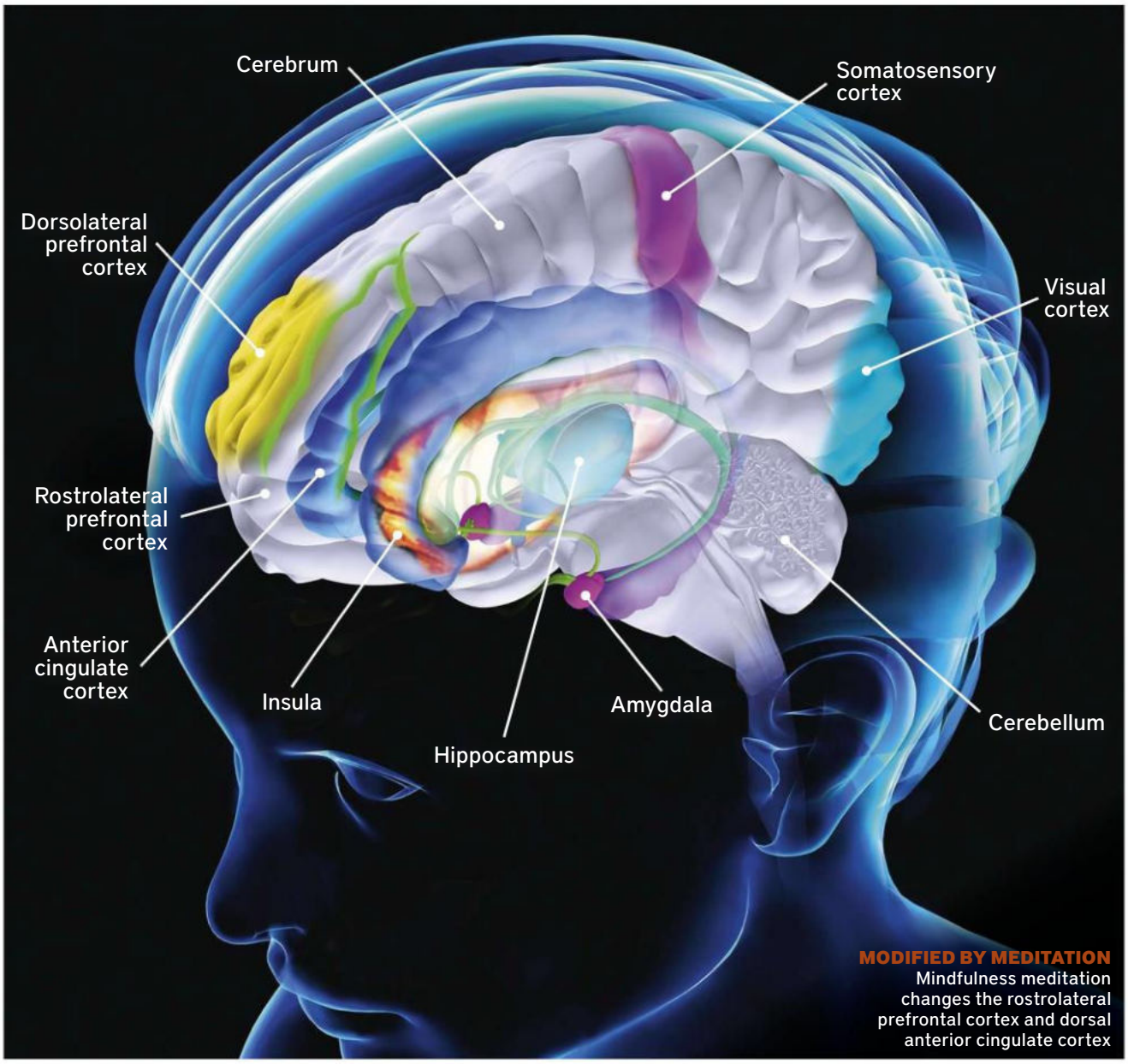
GETTY IMAGES

PREPPING FOR AN MRI SCAN Richard J. Davidson (centre), director of the Waisman Lab for Brain Imaging and Behavior, prepares Buddhist monk Matthieu Ricard (left) for an fMRI scan

BRAIN SCAN Graphic renderings of Matthieu Ricard's brain from a functional Magnetic Resonance Imaging (fMRI) scan done at the Waisman Lab at the University of Wisconsin-Madison

WIRED UP Sitting in a sound-proof room, Buddhist monk Matthieu Ricard is wired up to an electroencephalogram (EEG). Small sensors that are attached to the scalp pick up the electrical signals produced when brain cells send messages to one another

UNIVERSITY OF WISCONSIN-MADISON UNIVERSITY COMMUNICATIONS



MODIFIED BY MEDITATION
Mindfulness meditation changes the rostrolateral prefrontal cortex and dorsal anterior cingulate cortex

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cingulate cortex, or dACC. "This finding is intriguing because the dACC is generally thought to be an area critical to 'self-regulation' of various kinds – for instance, monitoring performance, making sure that behaviour remains adaptive and flexible under changing conditions, and controlling impulses," says Fox. "It's easy to see how a brain region with these functions could be involved in – and perhaps crucial to – meditation."

But he cautions against making simplistic inferences. "Until we can demonstrate that these structural changes are related to changes in cognitive ability or wellbeing, for instance, we shouldn't assume that these changes are necessarily good – or even meaningful."

Fox adds that the published studies may also be giving a biased picture of the truth. Researchers and journals tend not to bother publishing boring, negative results – and Fox and his colleagues found strong evidence of such 'publication bias'.

Many practitioners of mindfulness meditation will see scientific validation of its claims as a side issue, given their own experiences – and that of countless others over the centuries.

But for many others, like chronic pain sufferer Anne*, such validation helps combat doubts that so simple a technique really can bring such impressive benefits.

As Anne* puts it: "There is something very powerful about knowing there is physical objective proof that it's working." ■

**Some names have been altered.*

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